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PERFORMANCE MANUAL

FOR FMU-72/B BOMB FUZE

HONEYWELL INC.
ORDNANCE DIVISION

TECHNICAL REPORT AFATL-TR-68-143

DECEMBER 1968

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PERFORMANCE MANUAL FOR

FMU-72/B BOMB FUZE

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FOREWORD

This report documents work performed during the period 17 June 1963 to 1 January 1967 by Honeywell Inc., 600 Second Street North, Hopkins, Minnesota 55343, under Contract AF 08(635)-3745 with the Air Force Armament Laboratory, Eglin Air Force Base, Florida. Mr. James E. Wetzel (ATDF) was program monitor for the Armament Laboratory.

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This technical report has been reviewed and is approved.

John H Hobaugh

JOHN H. HOBAUGH, Colonel, USAF
Chief, Development Division

ABSTRACT

This document contains detailed descriptions of the FMU-72/B bomb fuze, the operation of the fuze, and the operation of the fuze subassemblies with their relationship to the arming and event functioning of the fuze, the performance values for the subassemblies with acceptable tolerances, and the effects of temperature, vibration, rough handling, impact, and G-force environments on the fuze subassemblies.

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SECTION I

DESCRIPTION OF FUZE OPERATION

A. GENERAL

The FMU-72/B Bomb Fuze (figure 1) was developed to meet the increased delivery-speed requirements and revised tactical requirements of present jet bomber aircraft. In this fuze, solid-state electronic circuitry replaces mechanical timing devices which experience difficulties at temperature extremes and at high-speed bomb impacts. A braided-steel arming lanyard replaces the classical arming wire and vanes which can cause bomb release difficulties at high speeds. This fuze is compatible with new series low-drag bombs containing internal plumbing. It is handled as a mechanical fuze by current aircraft bomb racks.

The fuze is mechanically initiated and is electronically programmed. It provides a choice of delays after bomb impact, with a range of from 20 minutes to 36 hours until detonation. The fuze will detonate the bomb after the selected delay elapses, or instantly if the bomb is disturbed after impact.

B. FUZE OPERATION

A complete description of fuze operation, either in a SAFE condition or in an ARMED condition, is presented in subparagraphs 1 through 3 and also in the block diagram, figure 2.

1. <u>Mission Preparation</u>

a. An FMU-72/B battery firing device and associated components are installed in a bomb.

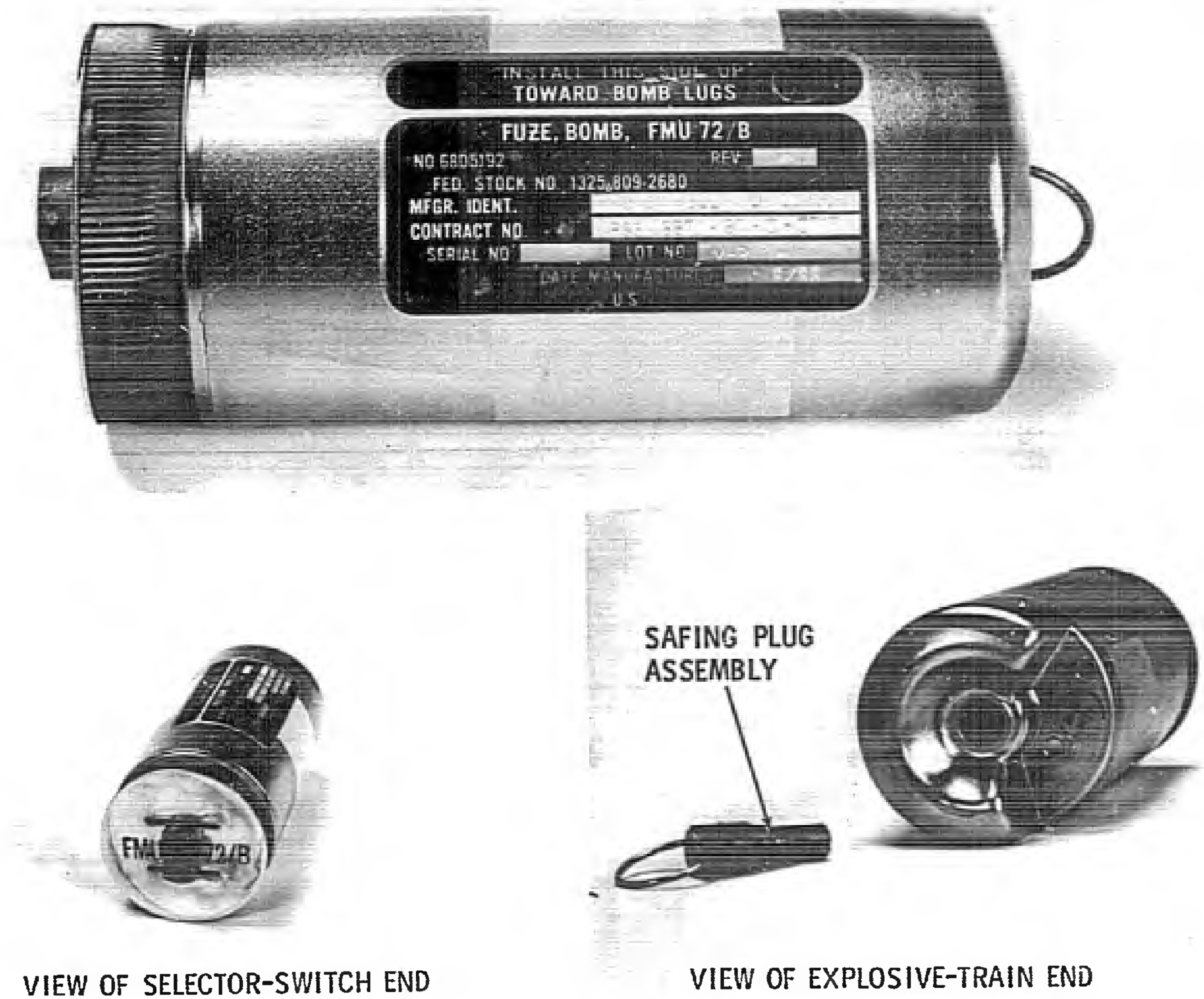


Figure 1. FMU-72/B Bomb Fuze

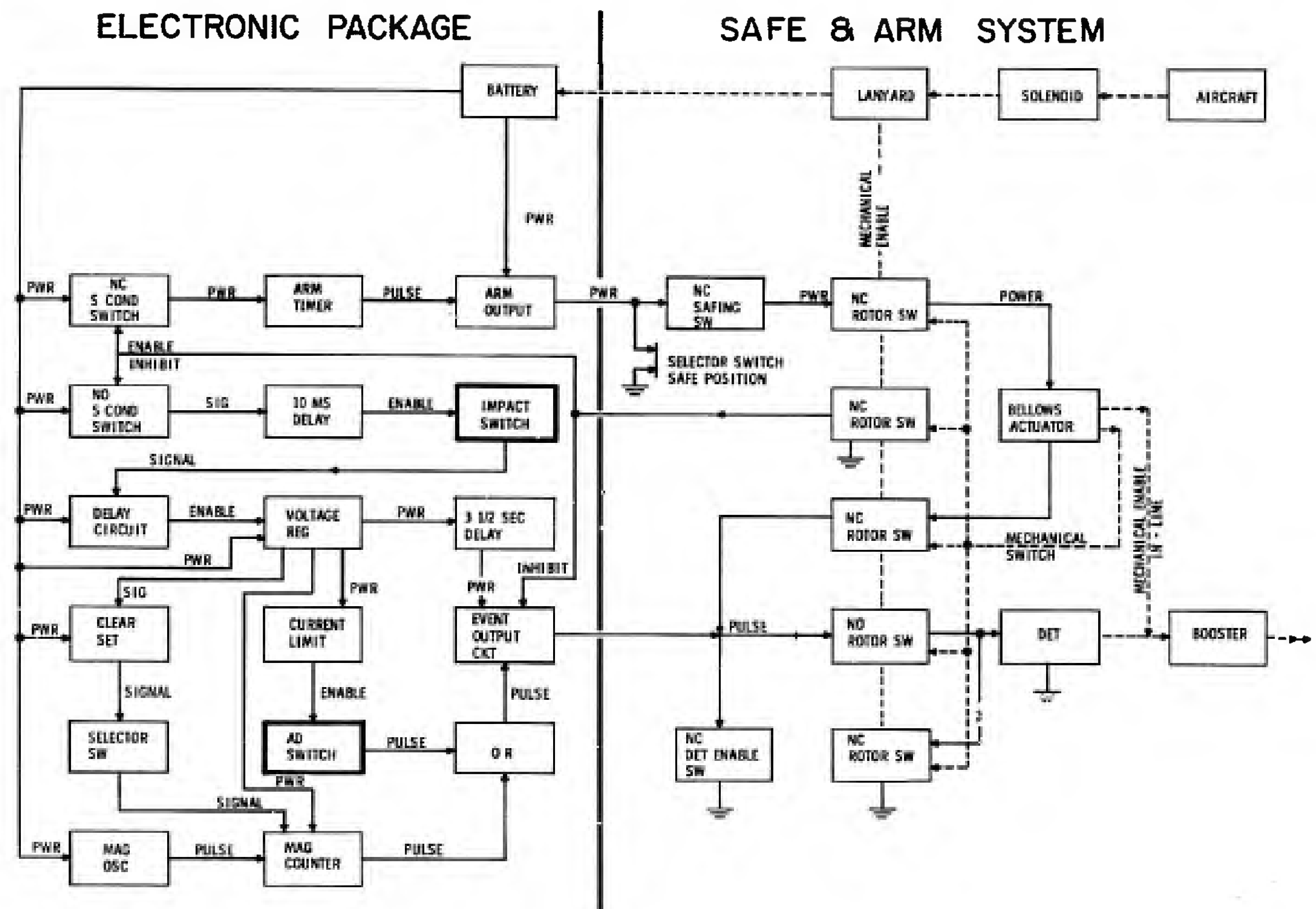


Figure 2. FMU-72/B Block Diagram

b. Each fuze is inspected according to the munition-preparation instructions in the specific aircraft T. O.

c. The bomb is loaded on the aircraft bomb rack and the swivel and link assembly is connected to the ejector-rack arming solenoid. This completes the mechanical interface between the bomb arming system and the battery firing device.

d. The fuze is set to the desired time delay with the delay selector.

e. An RDX booster is attached to the fuze.

f. The safe plug is removed. (The safe plug places a mechanical block on the rotor.) If the fuze is dropped at this time, the safing switch will open the arming circuit and dud the fuze.

g. The fuze is inserted on the battery firing device in the bomb fuze well. (The battery firing device places a mechanical block on the rotor until the lanyard is pulled.)

2. <u>Bomb Released From Aircraft In Safe Configuration</u>

The bomb is dropped safe, i. e., the arming lanyard is not pulled. Impact shock functions the safing switch and opens the arming circuit.

3. <u>Bomb Released From Aircraft In Armed Configuration</u>

(a) At T_0 (Bomb Drop Time):

- The arming lanyard is pulled.
- The firing pin in the battery firing device strikes the percussion cap on the ammonia battery, and the battery is activated.

(b) At T_{BA} (Battery Activated Time) = T_0 + 0.75 Second (Nominal):

- Battery activation supplies power to the arming timer, arm output silicon controlled rectifier (SCR), anode of impact SCR, voltage regulator, and magnetic oscillator.
- (If the bomb impacts earth prior to mechanical arming, the safing switch contacts open the circuit to the bellows motors, and the fuze cannot arm.)

(c) At T_{MA} (Mechanical Arming Time) = $T_0 + 6.0 {}^{+1.5}_{-1.0}$ Seconds:

- The bomb does not impact and continues to fall. At time $T_0 + 6.0 {}^{+1.5}_{-1.0}$ seconds, an arming signal is generated, and the bellows motors are fired.
- The bellows motors move the detonator in line with the RDX booster.
- The arming circuit is opened.
- A direct ground for the bellows motors replaces the ground through the detonator enable switch.
- The diode clamp circuit across the event capacitors is removed.
- A ground short across the detonator through the detonator enable switch replaces the direct rotor switch ground short.
- Signal voltage is applied to the 10-millisecond impact switch delay circuit.

(d) At $T_{MA} + T_{ISE}$ (Impact Switch Enabling Time) = $T_0 + 6.0 {}^{+1.5}_{-1.0}$ +0.010 seconds, signal voltage is applied to the impact switch.

(e) At T_I (Impact Time) = $T_0 + 6.0 {}^{+1.5}_{-1.0} + 0.010$ + Time of Bomb Flight:

- The bomb impacts.
- Power is applied to the 33 ± 10-second delay timer through the impact circuit.

- The detonator is enabled by removing the short across the device.

(f) At T_{CA} (Complete Arming Time) = $T_I + 33 \pm 10$ Seconds, a turn-on signal is applied to the voltage regulator, and

- Power is applied to the clear-set circuit of the magnetic counter modules.
- A voltage is applied to the antidisturbance switch circuit.
- Charging current is applied to the event output circuit.
- Power is applied to the magnetic counters.
- Arming is completed.

(g) At T_E (Event Time) = $T_I + 33 \pm T_{Set}$ Hours + (5% of T_{Set}) $\pm$ 2 Minutes:

- The magnetic time delay circuit will generate an event signal at the time preset by the delay selector; or,
- The antidisturbance switch and circuit is energized 33 ± 10 seconds after impact; if the bomb and/or fuze is disturbed after this time, the fuze will generate an instantaneous event signal.

SECTION II

OPERATION OF THE SUBASSEMBLIES RELATED TO THE SETTING, INITIATING, ARMING, AND EVENTING OF THE FMU-72/B BOMB FUZE

A. GENERAL

This section is an expansion of the previous section which described fuze operation in terms of the interplay of all the subassemblies. In this section, operational descriptions of the individual subassemblies are presented.

B. OPERATION OF THE SELECTOR SWITCH IN THE SETTING OF THE FUZE

The selector switch subassembly (figure 3) of the electronic assembly is comprised of a printed circuit board to which a band of four, electroplated, concentric conductive paths (switch plate) is attached on the reverse side. Various segments of the outer three conductive paths are tied, through the printed circuit, to magnetic cores of the binary magnetic counter (bimag counter) (figure 4). The inner path, conductive for positions 1 through 35, is the switch common tied to the anode of the silicon-controlled rectifier CR3 in the arming timer subassembly A6 (figure 10), and is also tied to ammonia battery B+ through the series-connected, clear-set line of magnetic cores in the bimag and decade counters (figures 5 and 20). (NOTE: Operations of the electronic subassemblies mentioned in the foregoing discussion are described in subsection D, ff.

A wiper in a wiper plate located in the setting knob shorts across all four conductive paths and connects the common (anode of CR3) to up to five magnetic cores of the bimag counter. The following paragraph contains a specific example of what takes place, mechanically and electrically, when an armorer selects a time delay to set into a given fuze according to his Specialist Job Request (SJR).

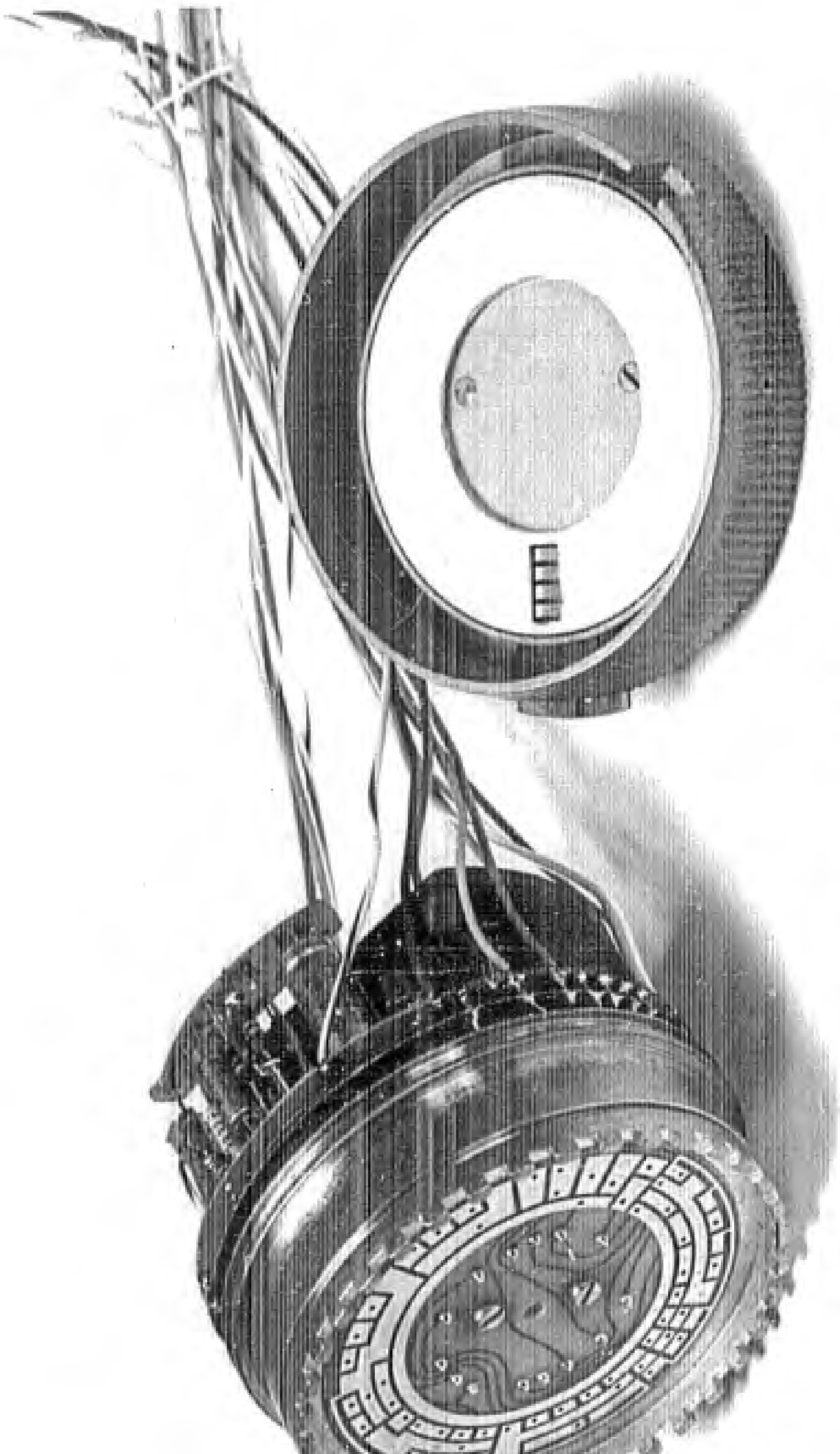


Figure 3. Selector-Switch Assembly

120

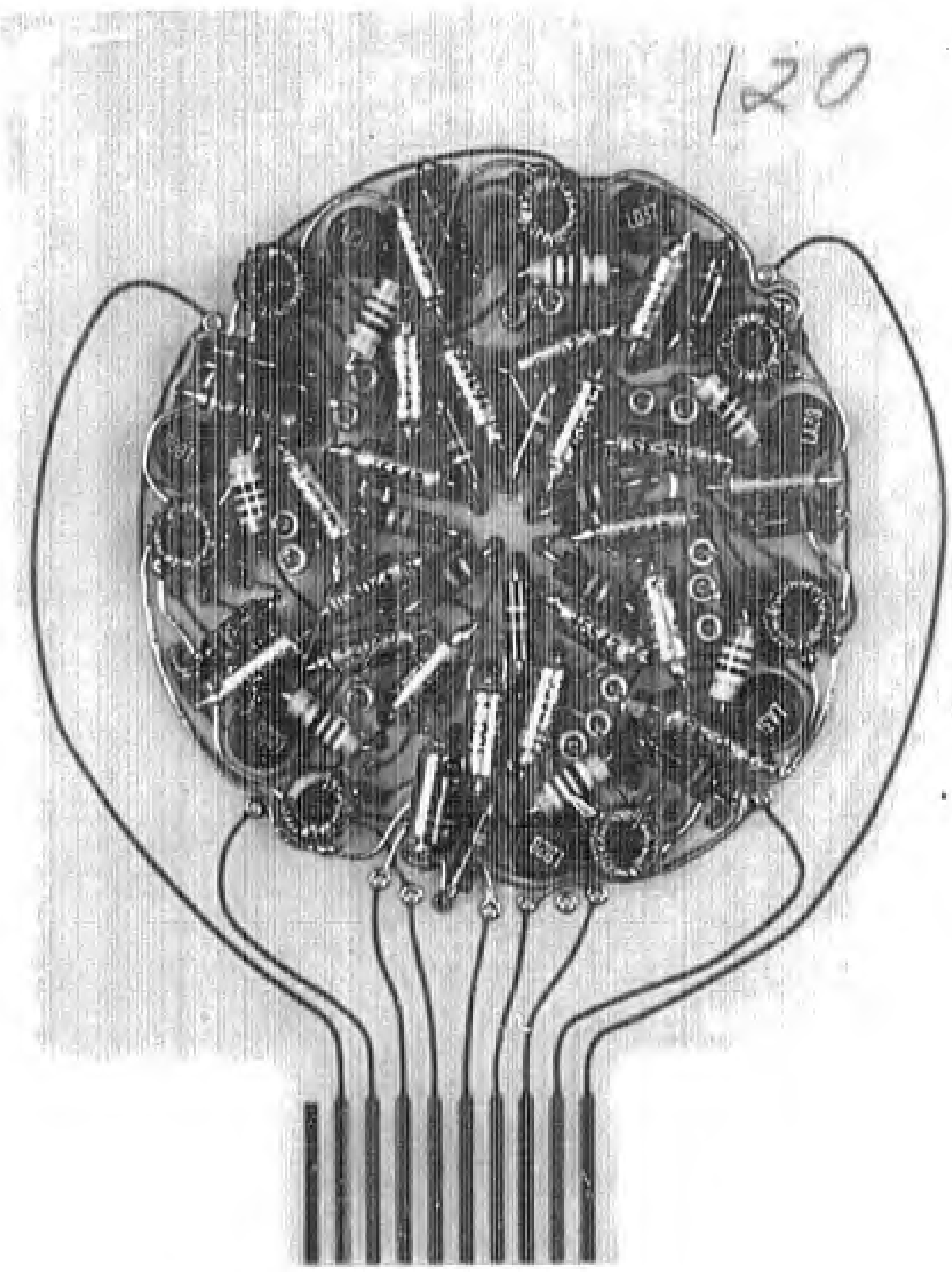


Figure 4. Binary Magnetic Counter

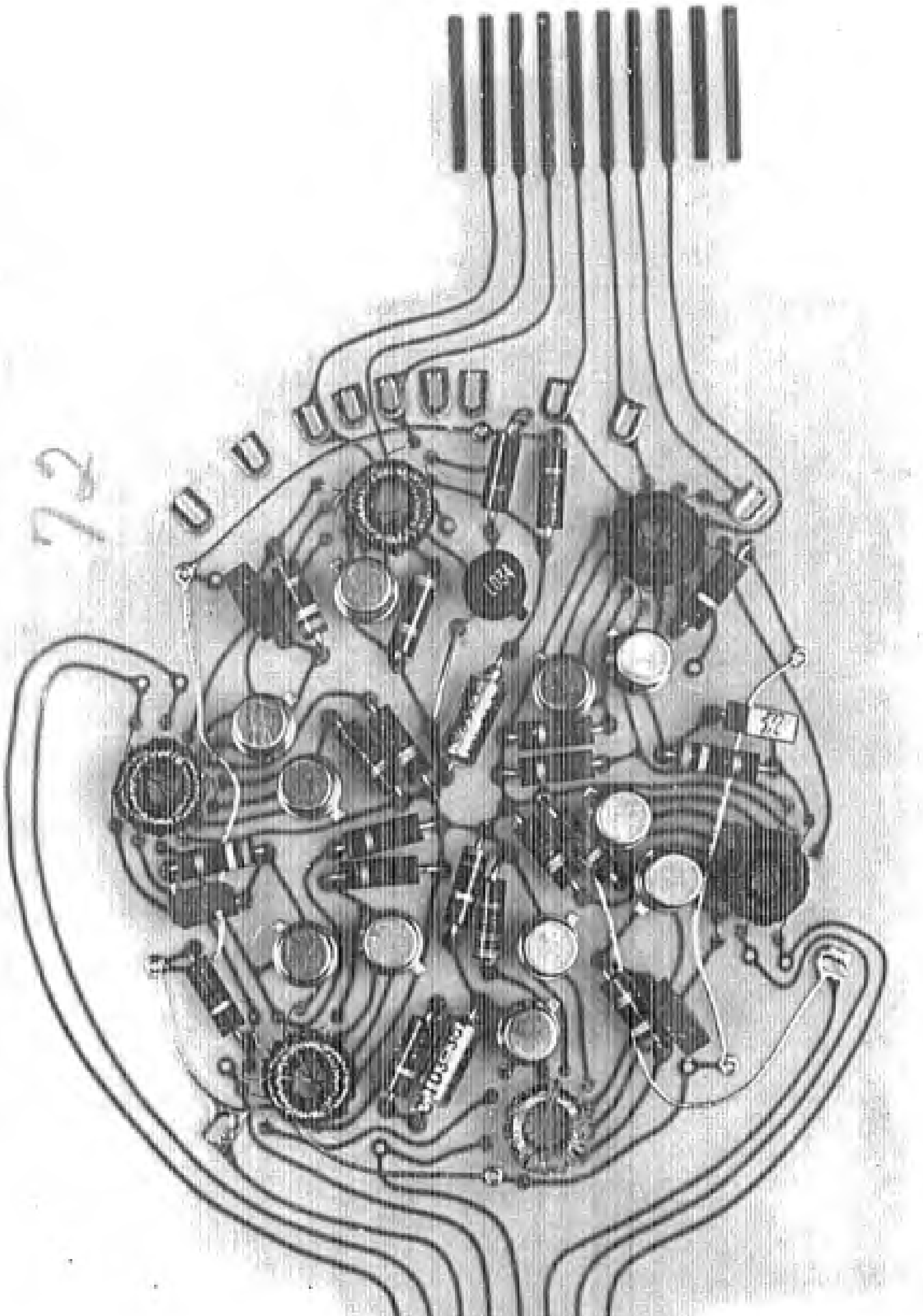


Figure 5. Decade Magnetic Counter

Assume that a delay time of three hours is required for this fuze. First, the armorer unlocks the slider on the setting knob (figure 1) by moving it in the indicated direction. Next, he rotates the setting knob until the numeral 3 appears in the notched viewing port. Third, he locks the setting knob by moving the slider in the indicated direction.

When set for this time delay, the wiper of the wiper plate within the setting knob contacts all four of the concentric conductive paths, but only one of these paths at this location of the wiper is electrically tied to magnetic core (T_4) in the bimag counter module through contact W_7 of the selector switch. The simplified schematic (figure 6) shows the electrical circuit involved in the three-hour setting of the selector switch. Also refer to figure 28 of Section V.

C. OPERATION OF THE SWIVEL AND LINK ASSEMBLY, BATTERY FIRING DEVICE, AND AMMONIA BATTERY IN INITIATING THE FUZE

1. Fuze Initiation (Bomb Released Armed)

With the aircraft arming selector switch set in the NOSE/TAIL or TAIL ONLY position (F100 plane, for example), the arming solenoid is energized, extending the arming pin. At bomb release, the extended arming pin holds the ring of the swivel and link assembly (figure 7), pulling the lanyard cable. The pulled lanyard cable activates the battery firing device (BFD) (figure 8), and the spring-released firing pin in the BFD initiates a percussion-cap-activated ammonia battery (figure 9). As the battery functions, the voltage rises to a minimum of 7.2 vdc and a maximum of 14.0 vdc. Activation time for these voltages ranges from 0 to 1250 milliseconds.

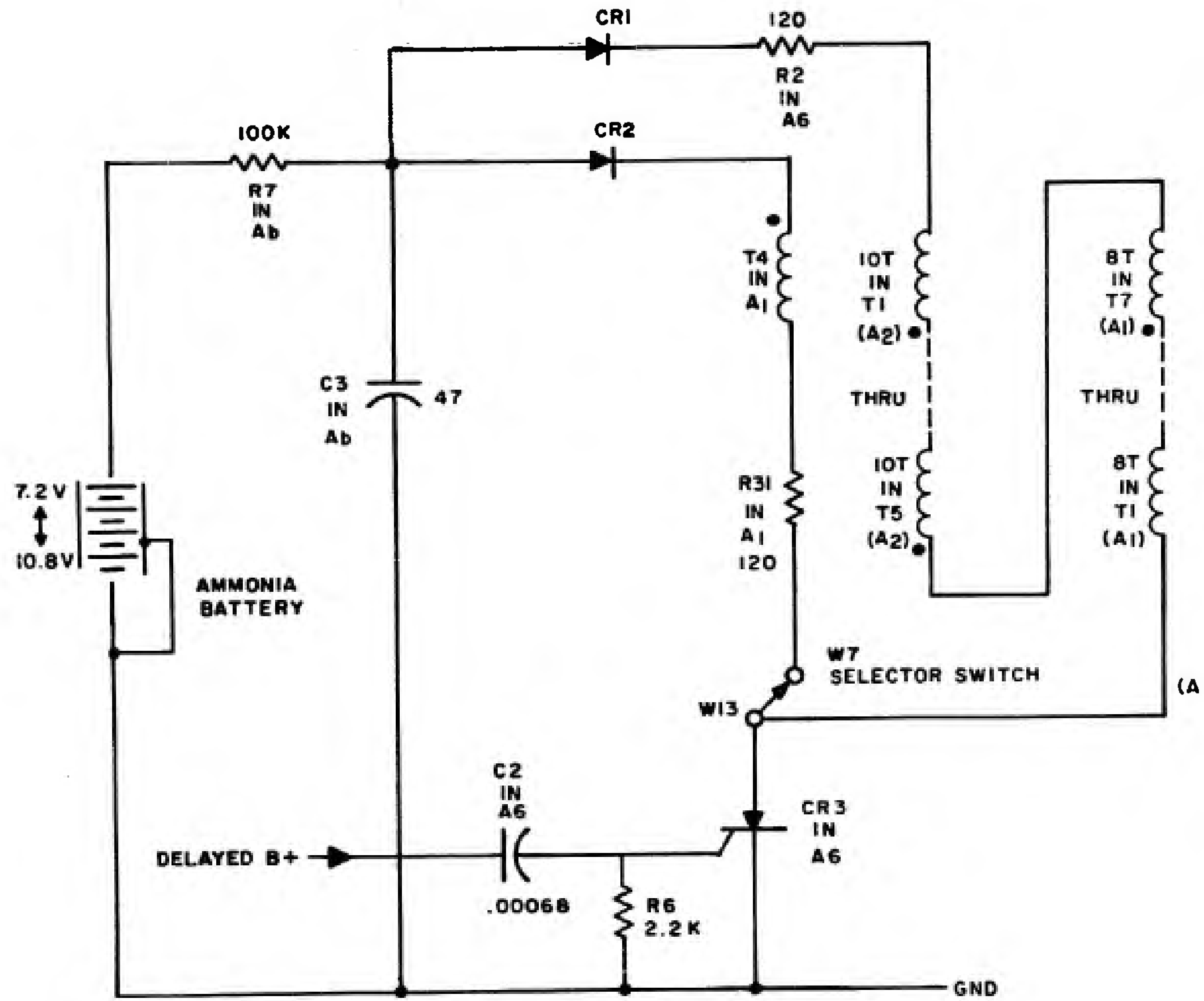
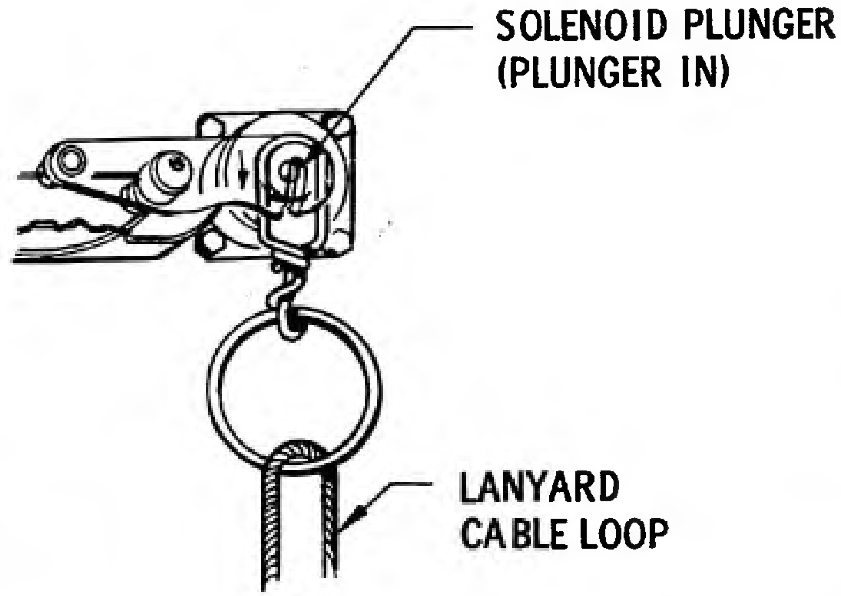
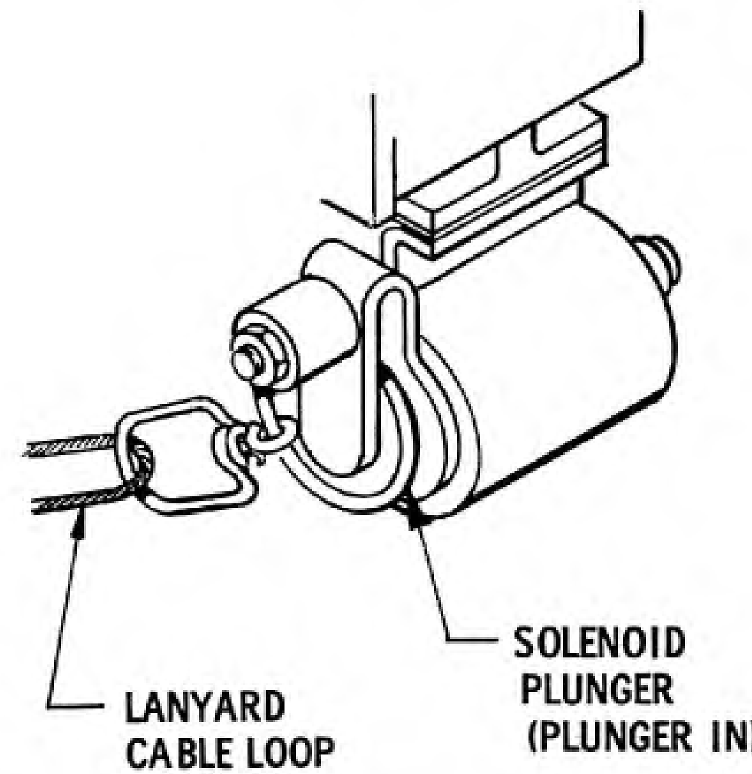


Figure 6. Simplified Schematic of Core Selection and Associated Circuitry for a Three-Hour Delay Setting



TYPICAL INSTALLATION -
RECTANGULAR RING INSERTED INTO
SOLENOID UNIT



F105D AIRCRAFT OUTBOARD RACK
INSTALLATION -
ROUND RING INSERTED INTO
SOLENOID UNIT

Figure 7. Swivel and Link Assembly Ring Selection

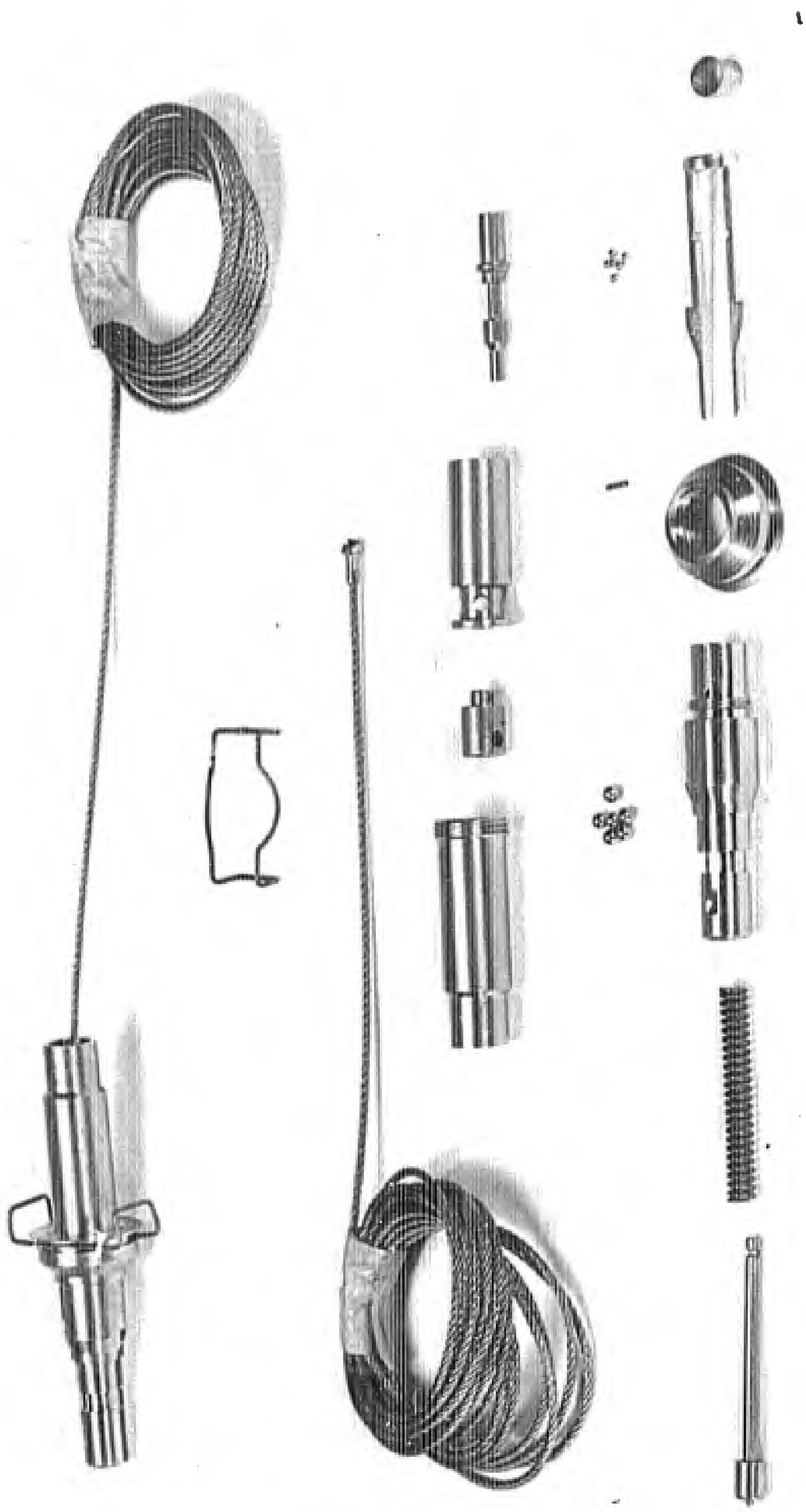


Figure 8. Battery Firing Device

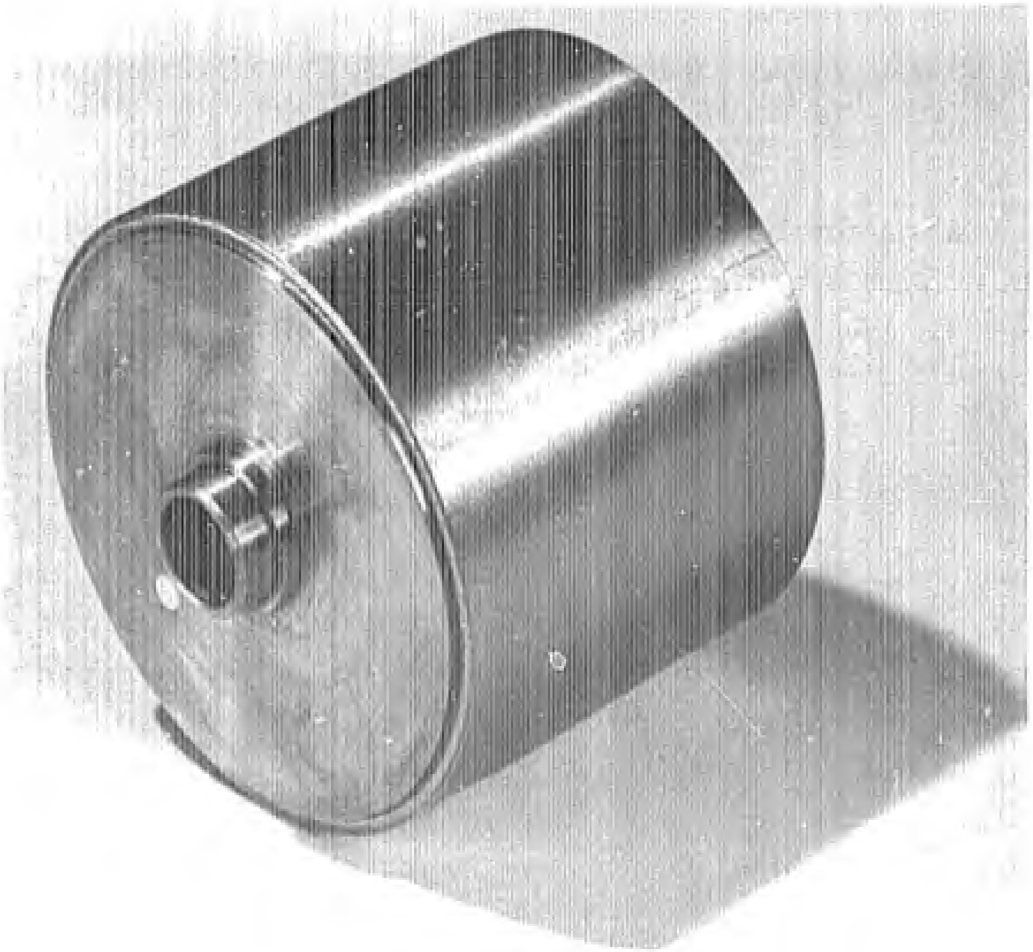


Figure 9. Liquid Ammonia Battery

2. Bomb Released Safe

With the aircraft arming selector switch set in the SAFE position (F100 plane, for example), the arming pin remains recessed. At bomb release, the ring of the swivel and link assembly is withdrawn from the friction-hold section of the arming solenoid, and the swivel and link assembly and lanyard cable fall away with the bomb without initiating the battery.

D. OPERATION OF THE ELECTRONIC SUBASSEMBLIES RELATED TO ARMING

Figure 28 is a simplified schematic of the fuze electronics as well as of the switch subassemblies which make up the FMU-72/B fuze system. While considering the operational details of the individual subassemblies, keep figure 28 unfolded for a ready reference.

1. Arming Timer

The arming timer performs three functions sequentially. First, the timer senses the rise of the battery voltage to a predetermined level. Second, when the predetermined voltage level is reached, the arming timer applies the battery voltage to the arming delay circuit. Third, approximately 6.0 seconds after initiation of the battery, the arming delay circuit produces a delayed output pulse which initiates the bellows circuit. Paragraph F-2 describes the remaining portion of the arming timer, the clear-set circuits.

The level of the battery voltage is sensed with the circuit comprising resistor R_1 and transistor Q_2 in figure 10. When the battery voltage exceeds approximately 3.4 vdc, PNP transistor Q_2 switches "on" and applies the battery voltage to conventional unijunction oscillator containing Q_1, which functions as a delay circuit. C_1 charges through R_3 until the capacitor voltage reaches a fixed level. Then Q_1 conducts from emitter (e) to base one (b_1), discharging C_1 through R_5, and providing a positive delayed output pulse.

2. Bellows Motors Arming Output Circuits (figures 11 and 28)

Ammonia battery B+ is applied directly to the anode CR1 0.75 second after bomb release and battery initiation. CR1 fires upon application of the delayed input pulse from the arming timer on the CR1 gate at a time $6.0^{+1.5}_{-1.0}$

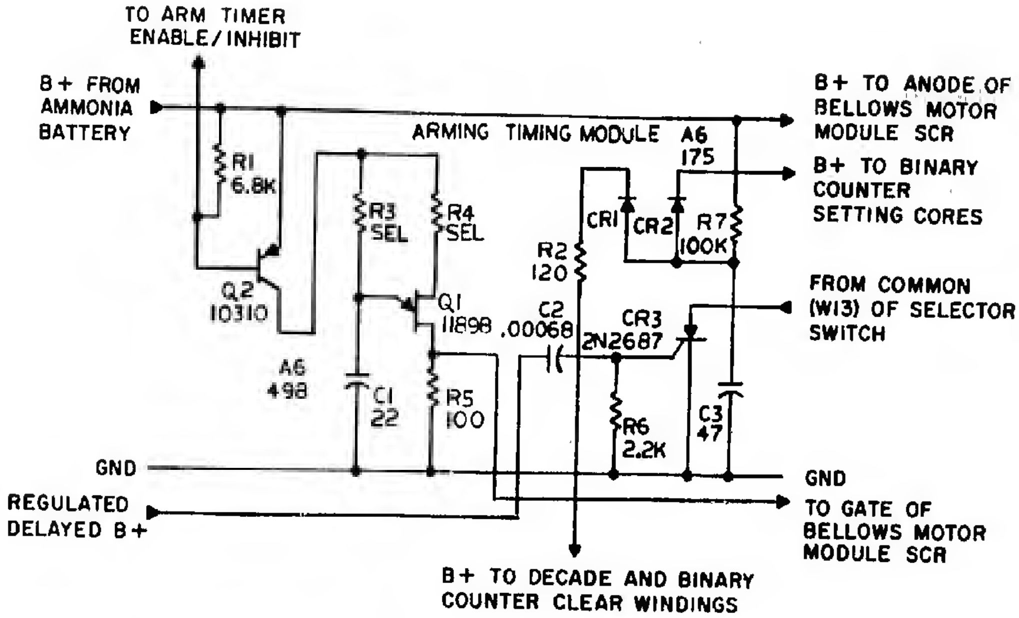


Figure 10. Arming-Timing-Module Schematic

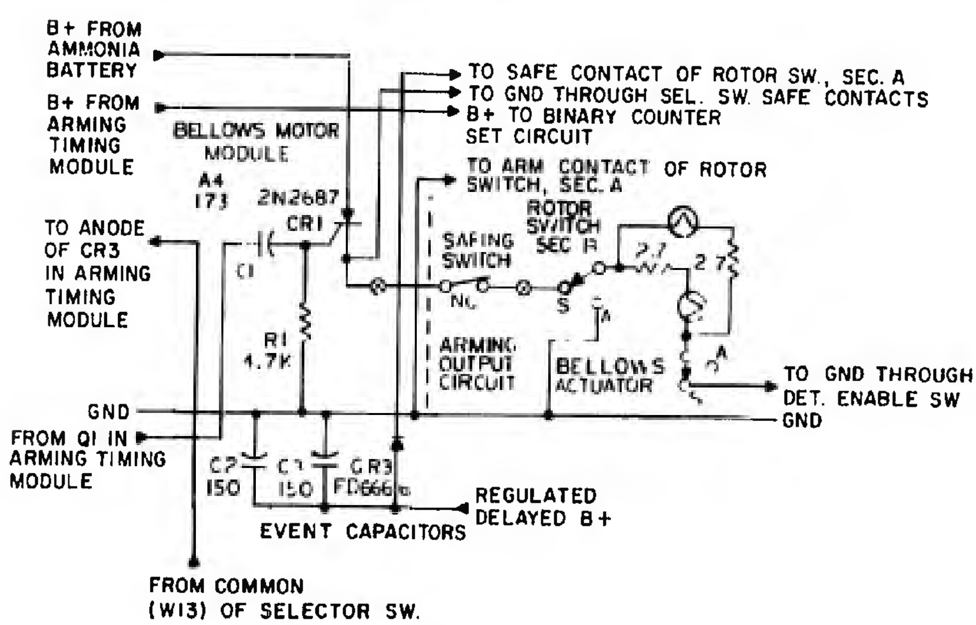


Figure 11. Bellows-Motor-Module and Arming Output-Circuit Schematic

seconds after bomb release. Battery power causes explosions to occur in the bellows motors, and the resulting expansion of the bellows drives the pistons to turn the rotor assembly with its five-section rotor switch approximately 90 degrees. The rotor turning also mechanically aligns the detonator with the booster.

If a bomb is accidentally dropped from a parked aircraft, impact occurs approximately 0.7 second after bomb release and the safing switch opens. (The safing switch opens permanently when subjected to a half-sine wave shock of 125-g maximum with a duration of 5.0 milliseconds.) Even though SCR CR1 firing takes place approximately 6.0 seconds after the release, the open safing switch prevents operation of bellows motors and, therefore, arming.

Functioning of the energy storing capacitors, C2 and C3, and the diode clamp, is described in paragraph F-6.

E. OPERATION OF OTHER SUBASSEMBLIES INVOLVED IN FUZE ARMING

1. Safing Switch (figures 12 and 28)

The safing switch provides safety in the event of accidental ejection of a bomb at extremely low altitudes, or ejection from a parked aircraft. Electrically, this normally closed, single-pole, single-throw switch is in series with the bellows-motor-circuit output, the normally closed contacts of one section of the rotor switch, and the bellows motors. The switch is a wobble-mass-type switch in which the wobble mass is retained by a contract-bearing leaf spring, and will open by the thrust action of the mass when it is exposed to a predetermined shock level. The contacts are held open by the blocking action of a spring-loaded tab on the end of the spring after it has detented into the latch point.

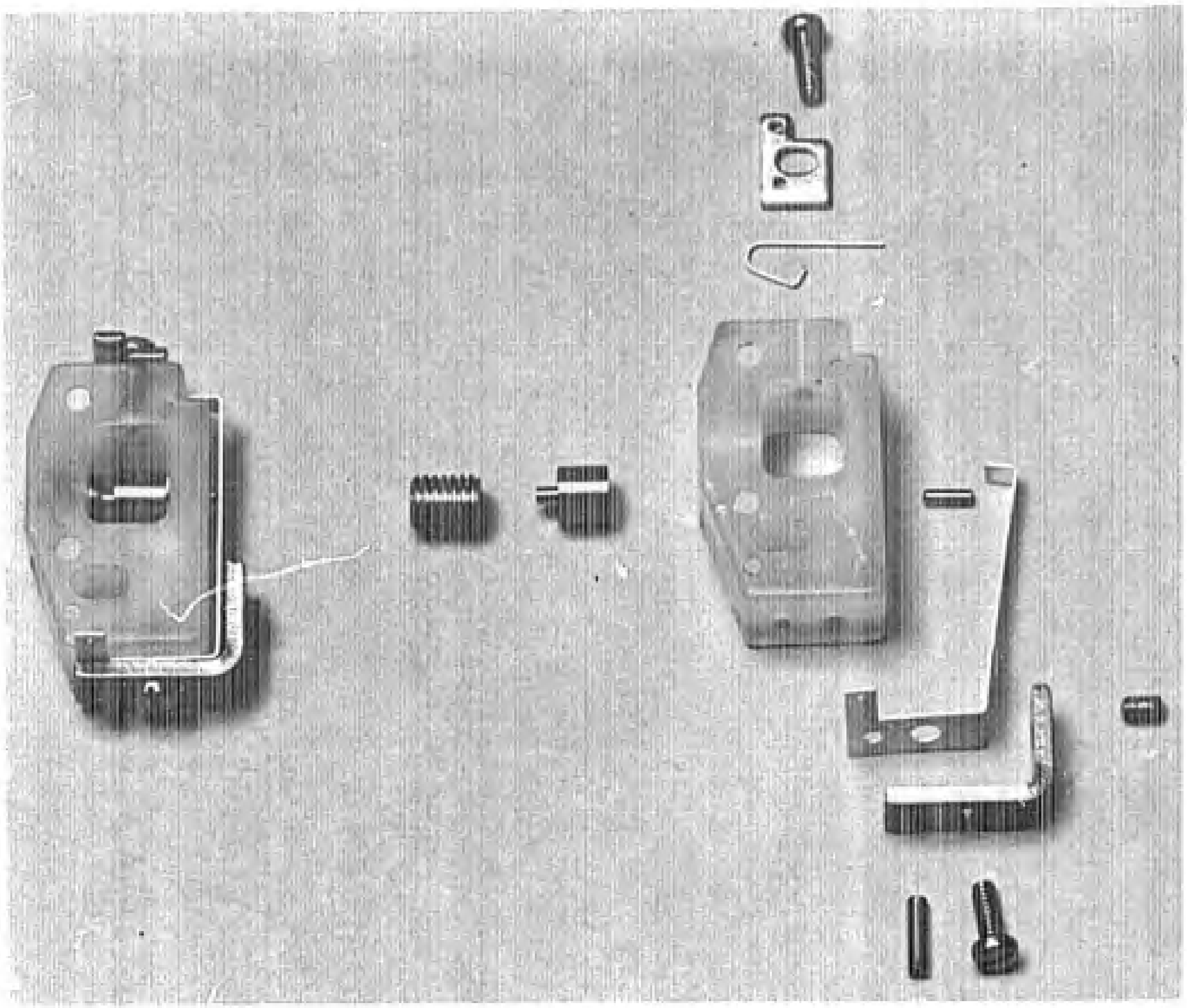


Figure 12. Safing Switch

2. Bellows Motors (figures 13 and 28)

The bellows motors provide the mechanical action to cause the rotor switch to rotate approximately 90 degrees to the armed position. At arming, an electrical pulse is supplied to the bellows motors from the arming timer circuit (see paragraph D-2), and the explosive (a gas-producing charge) within the bellows motors is fired. High pressures, created by the explosion, act against the bellows and cause them to extend. Extension of the bellows

along the channels in the rotor switch act against pistons which, in turn, react against the camming grooves in the rotor switch to turn the rotor switch. Two bellows motors are used redundantly to provide high reliability. Since the operating load is approximately half that of motion capability of one of the motors, either motor can turn the rotor-switch assembly.

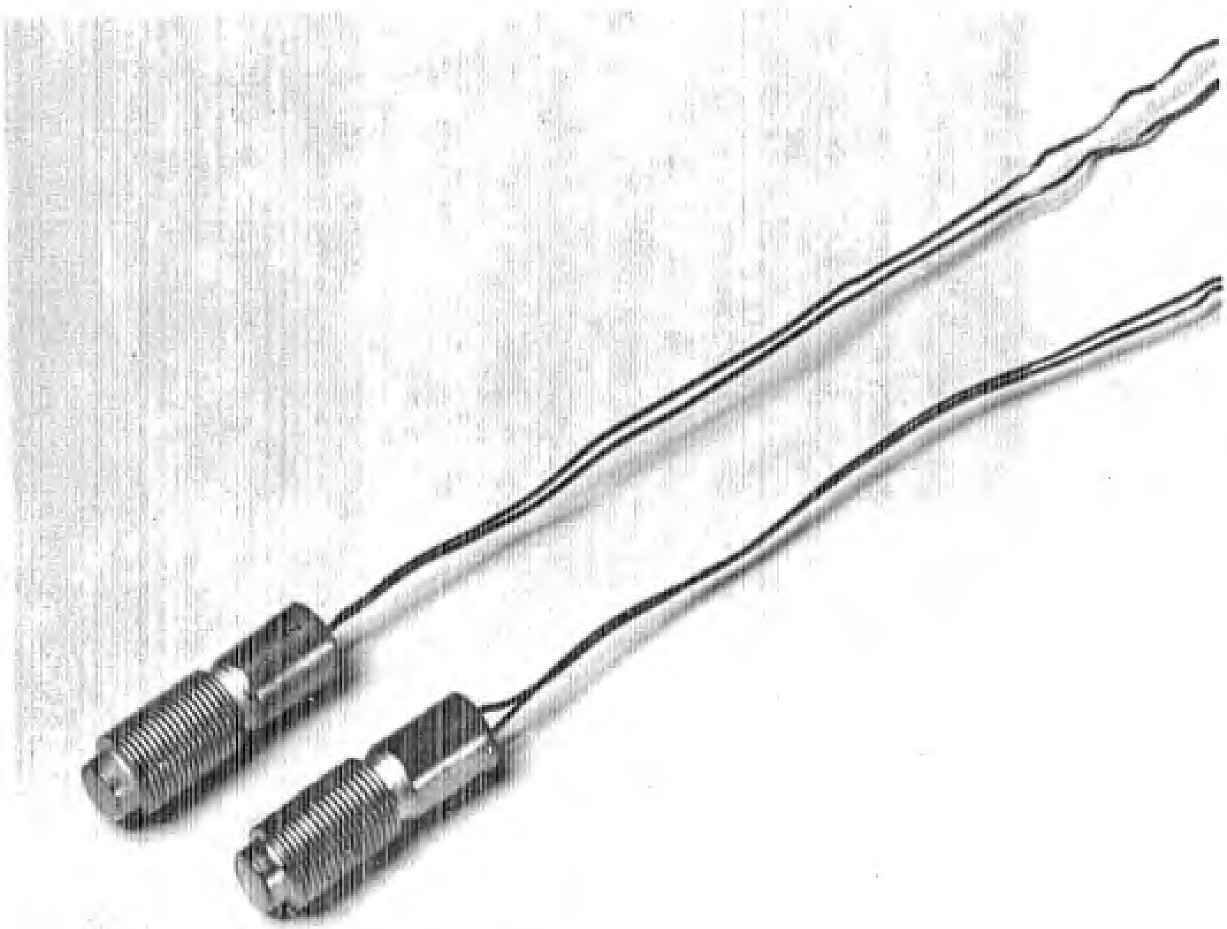


Figure 13. Bellows Motors

3. Rotor Switch Assembly (figures 14 and 28)

The rotor-switch assembly is a two-position, multi-pole, wafer-type switch which is turned to its "armed" position by the action of the bellows motors (see previous paragraph). In the "unarmed" position, the switch completes various electrical circuits; in turning to the "armed" position, the switch performs a mechanical function, breaks certain electrical circuits, and makes other circuits (see figure 28 and paragraph B-2).

F. OPERATION OF ELECTRONIC SUBASSEMBLIES INVOLVED IN FUZE EVENTING

1. Impact Delay

The impact delay circuit shown in figures 15 and 28 senses bomb impact and, after a fixed delay of 33 ± 10 seconds, applies a signal to turn on the voltage regulator.

Power is applied to the impact delay circuits 0.75 second after the battery is initiated. When the impact switch closes momentarily at impact, a positive signal is applied to the gate of silicon-controlled rectifier CR_1. CR_1 then conducts, applying B+ to the unijunction (Q_2) delay circuit. Components R_5 and C_2 of the delay circuit have been selected to provide an output pulse across R_7 in 33 ± 10 seconds. This pulse momentarily saturates Q_1 which drops B+ across R_2, extinguishing CR_1, and avoiding further current drain by the unijunction delay circuit.

a. Voltage Regulator Circuit

The voltage regulator shown in figure 16 regulates power to the decade and binary counters. As the battery voltage varies, CR_3 operation produces a counteracting voltage across R_4, keeping the output voltage constant.

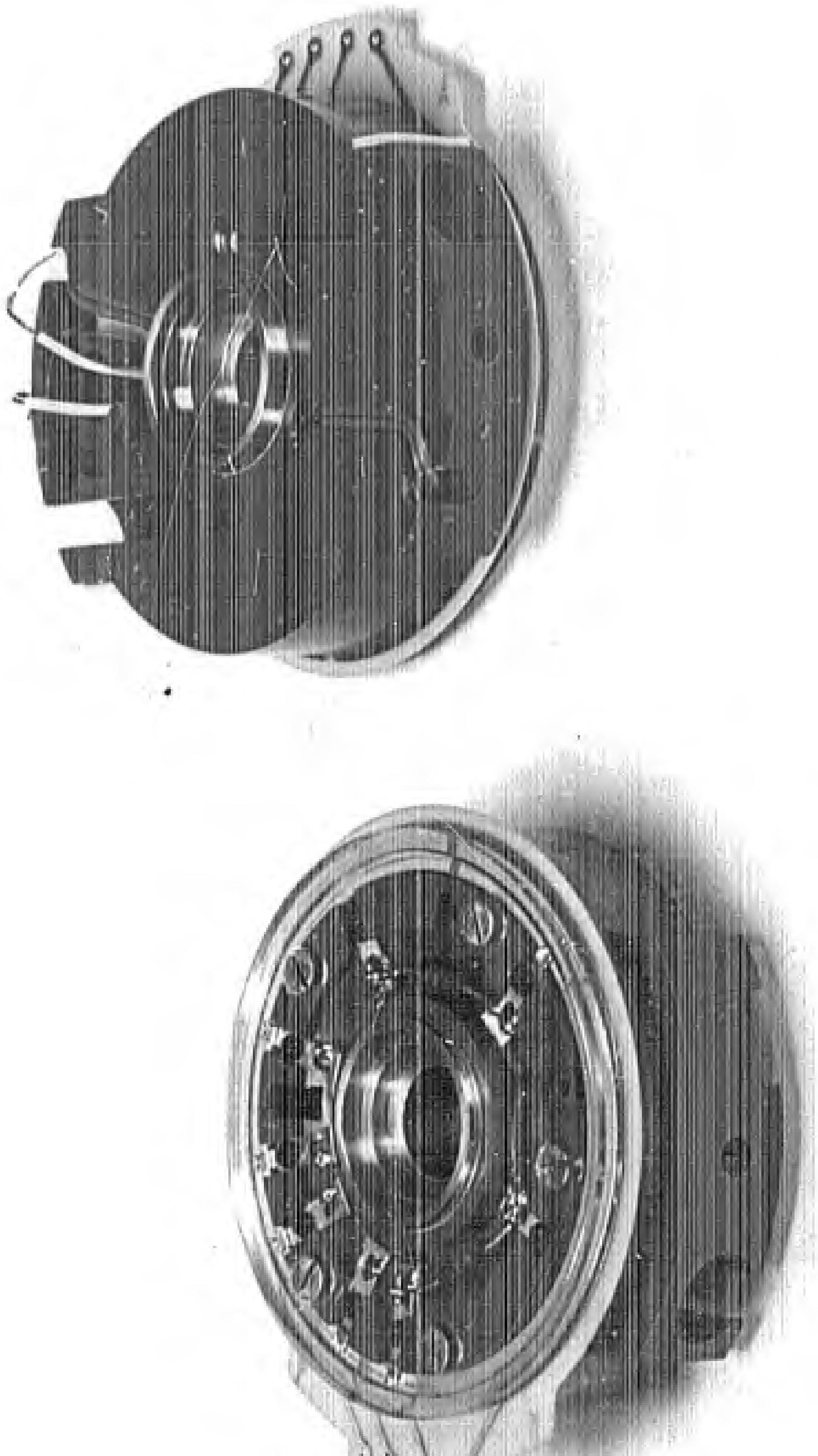


Figure 14. Rotor Switch Assembly

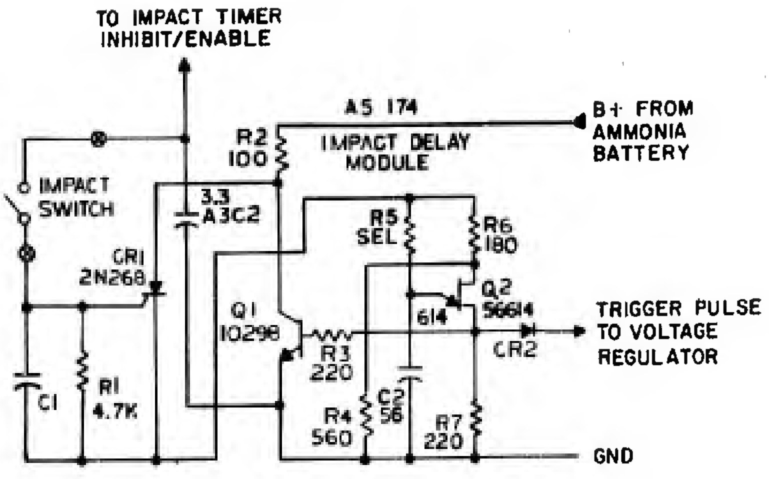


Figure 15. Impact-Delay-Circuit Schematic

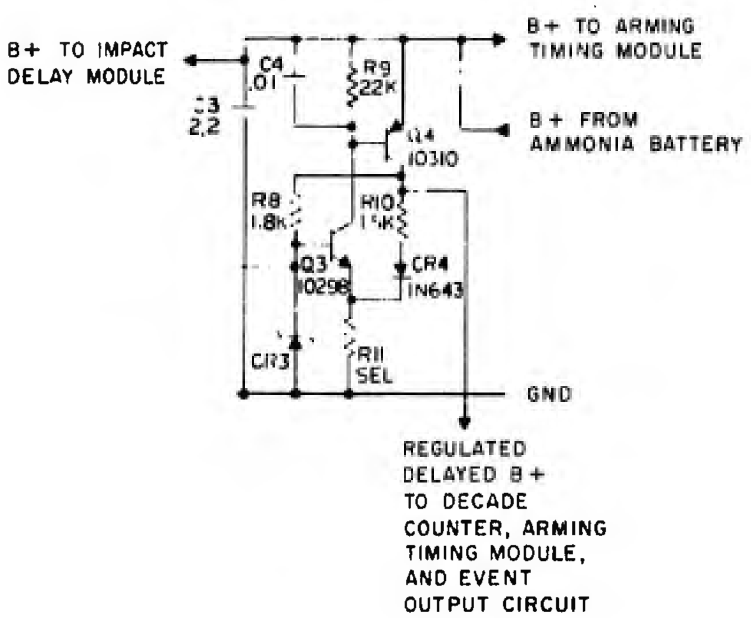


Figure 16. Voltage-Regulator-Circuit Schematic

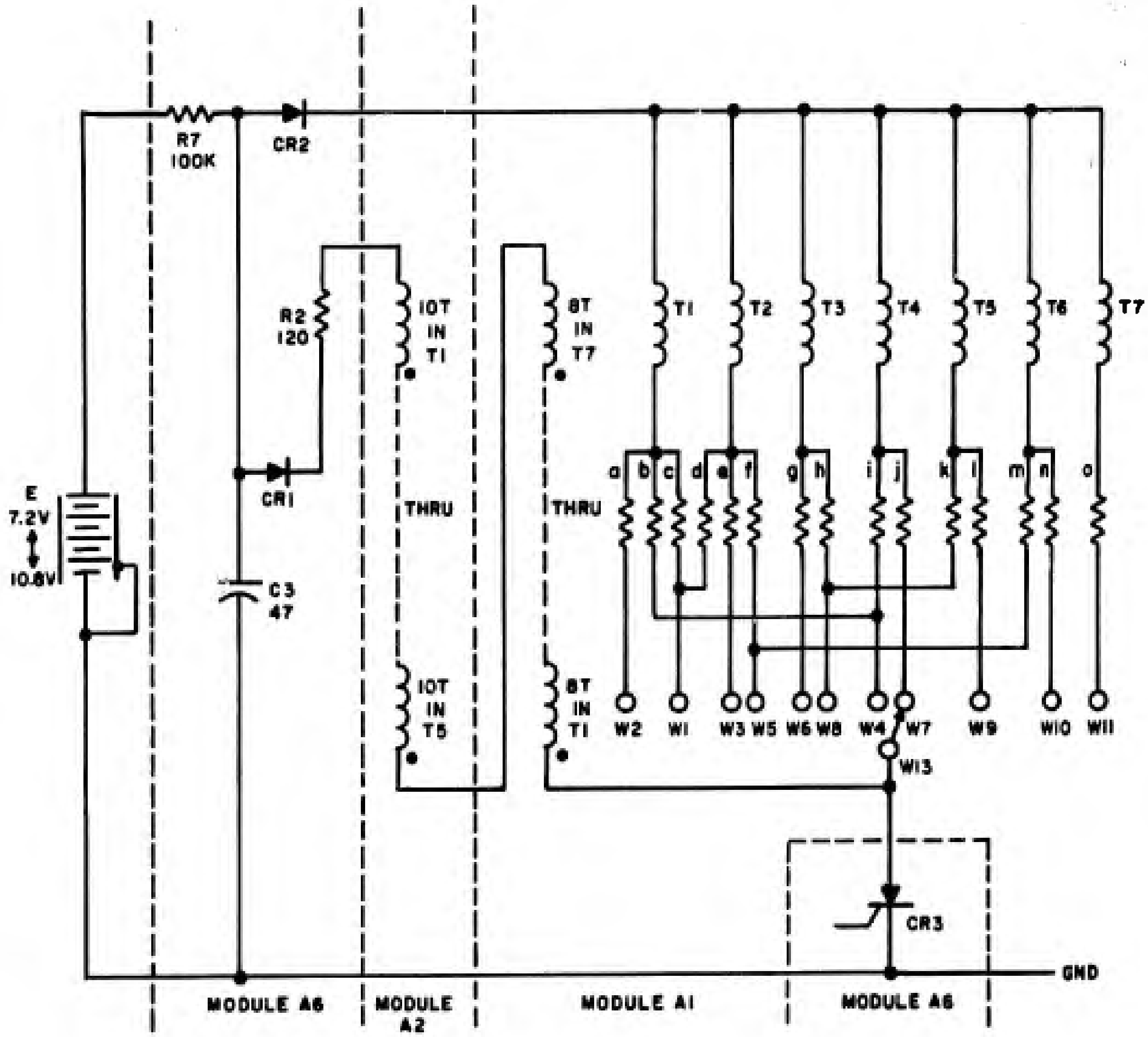
The output pulse from the impact time delay circuit (paragraph F-1) triggers Q_3 and Q_4 of the voltage regulator circuit. The two transistors function in a manner similar to that of a silicon-controlled rectifier. Collector current of one transistor provides base current for the other in a regenerative manner until the base voltage of Q_3 is damped by CR_3 to approximately 4.7 volts. The voltage at the junction of CR_4 and R_{10} is equal to the reference voltage across CR_3, and the output voltage is an uneven multiple of the reference voltage. Resistor R_{11} is selected to provide the desired reference voltage.

2. Clear Set

At the end of the impact delay, the delayed B+ is applied to the clear-set circuit in each of the two counter modules. Simultaneously, the clear-set circuit clears all of the decade cores, all of the cores in the binary circuit which are not to be set, and sets the remaining binary cores. Impact shock does not alter the desired magnetic state of the cores, since these clear-set functions occur after impact.

Capacitor C_3 charges through R_7 to provide stored energy for the clear-set function. At the end of impact delay, SCR CR_3 is triggered by the delayed B+. Capacitor C_3 then discharges through the toroid assemblies, as shown in the equivalent circuit (figure 17).

The clear windings of the decade and binary circuits are in series with CR_4. The binary set windings are in parallel and contain twice as many turns as the binary clear windings. Consequently, if current is applied to both the set and clear winding of a given core, the core will set. If current is not applied to the set winding of a given core, the core will clear. The selector switch determines which cores are set. After C_3 discharges through the windings, CR_3 turns off and the clear-set circuits are not used again.



SET RESISTOR NUMBERS (ALL ARE 120 Ω):

a = R22	d = R25	g = R28	j = R31	m = R34
b = R23	e = R26	h = R29	k = R32	n = R35
c = R24	f = R27	i = R30	l = R33	o = R36

Figure 17. Simplified Clear-Set-Circuit Schematic

a. Magnetic Core Logic Conventions

The following magnetic-core logic conventions (figure 18) are used in explaining the magnetic-core counter system:

- A core in positive saturation is in a set state (stores a "1") (point A, view A).
- A core in negative saturation is in a clear state (stores a "0") (point B, view A).
- Current flowing into the undotted end of any winding clears the core (sets the core to the "0" state) (view B).
- Current flowing into the dotted end of any winding sets the core (sets the core to the "1" state) (view C).

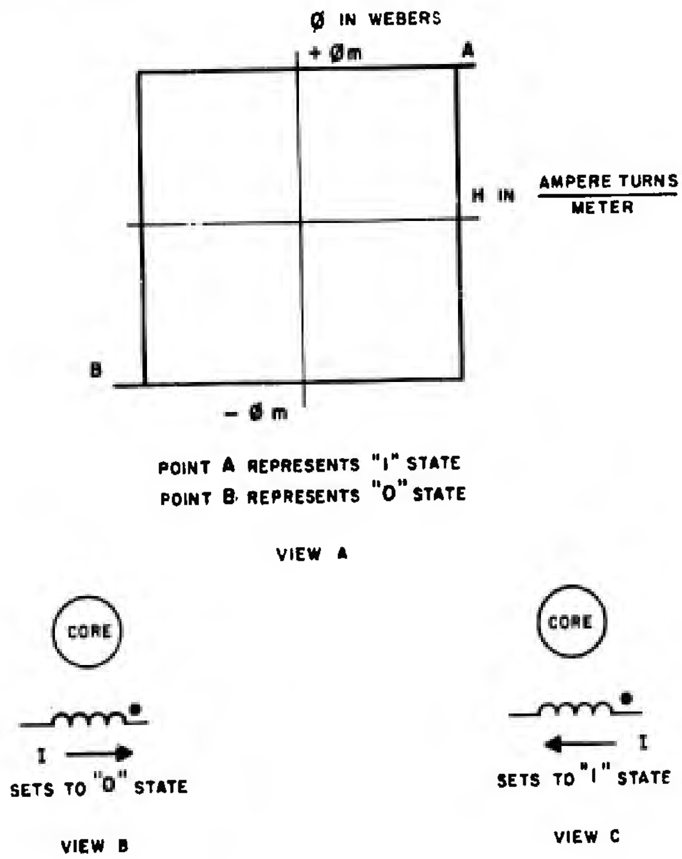


Figure 18. Magnetic-Core Logic Conventions

3. Magnetic Oscillator

Battery B+ operates the magnetic oscillator which provides an 8. 33-Hertz (Hz) time base.

As shown in figure 19, Q_1 and Q_2 comprise a voltage regulator for the magnetic oscillator. The regulator provides an output voltage across R_3, independent of battery voltage and dependent on temperature, to compensate for the magnetic core. CR_2 functions as a voltage reference. CR_1 provides temperature compensation for the base-to-emitter junction of Q_2. The voltage across R_3 approximates the voltage across Zener diode CR_2; Q_1 and Q_2 maintain this condition.

Should the voltage across R_3 tend to decrease with respect to the reference voltage across CR_2, the collector current would increase in Q_2, thereby increasing collector current in Q_1, and correcting output voltage. CR_3 and sensistor RTI vary their resistance with temperature to modulate the current in CR_2 and, therefore, the output voltage in a manner which compensates for the characteristics of the magnetic core.

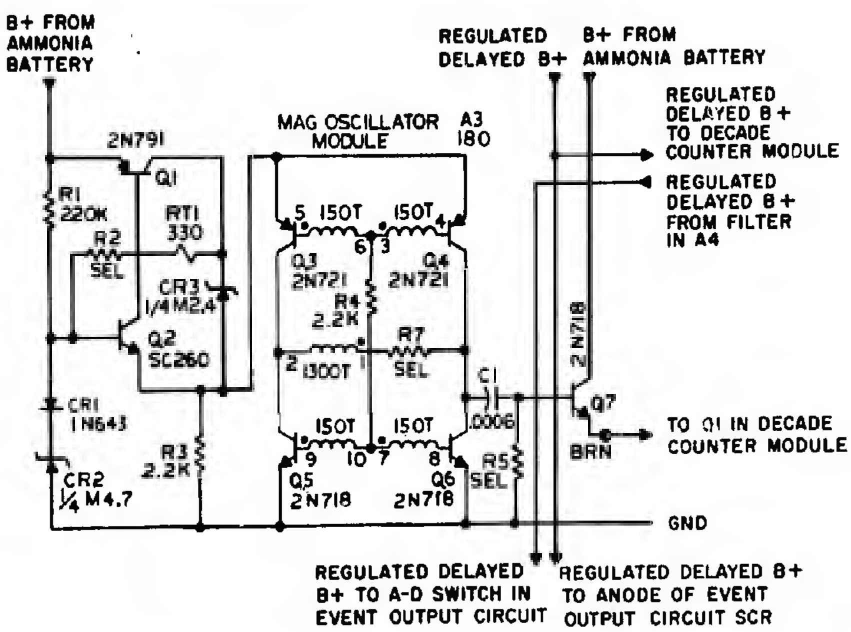


Figure 19. Magnetic-Oscillator-Circuit Schematic (Module A4)

The magnetic oscillator consists of a toroid assembly with a number of windings and four transistors. Assume the dot side of each winding is positive. Winding W_4 energizes Q_5, W_2 energizes Q_4, W_1 de-energizes Q_3, and W_5 de-energizes Q_6. Since Q_4 and Q_5 conduct, voltage across W_4 is positive on the dot side. Q_4 and Q_5 remain energized until the core is saturated. Then the magnetic field collapses and the dot side of the windings becomes negative, energizing Q_3 and Q_6 and de-energizing Q_4 and Q_5. The second half of the cycle is similar to the first, and terminates when the field collapses again. The emitter-follower stage consisting of Q7 provides impedance matching between the magnetic oscillator and decade counter.

4. Decade Counter

The decade counter consists of a blocking oscillator followed by two decade stages and another blocking oscillator followed by two more decade stages. The blocking oscillators provide pulse shaping. Each decade stage has one output pulse for each ten input signals. The four decade stages in series, therefore, have one output for each ten thousand input signals.

The input blocking oscillator shown in figure 20 consists of the circuit Q_1 and CR_1, both normally nonconducting. A positive pulse from the magnetic oscillator causes Q_1 to conduct momentarily. The collector current of Q_1 causes a voltage drop in the winding of T_1 between terminals 5 and 6, with the dotted side being negative.

The resultant transformer action induces a positive signal at T_1, pin 7. This signal maintains Q_1 in conduction until T_1 is saturated. When T_1 is saturated, a positive pulse is induced at T_1, pin 2, causing CR_1 to fire. Capacitor C_1 discharges and current decreases in CR_1; conduction in CR_1 stops and C_1 charges again through R_1. At this point, a quiescent state is established with no current conduction until another positive pulse is received from the magnetic oscillator, at which time the cycle is repeated.

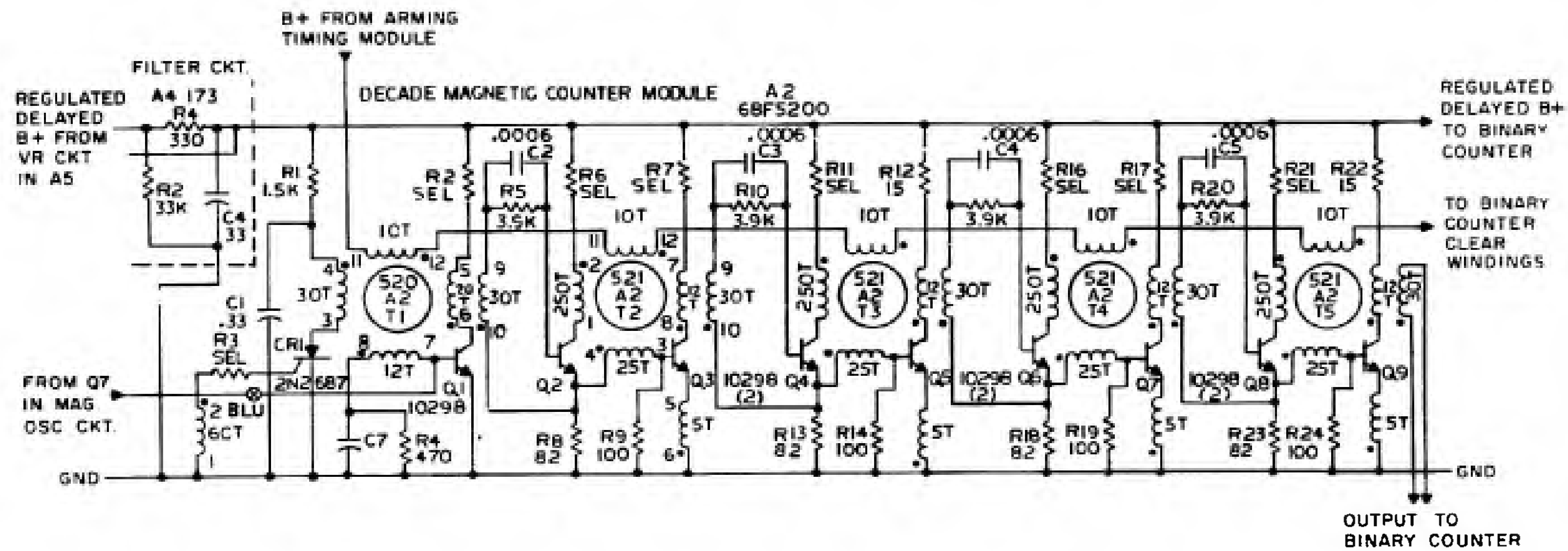


Figure 20. Decade-Counter-Circuit Schematic

The output of the blocking oscillator induced in winding 9-10 is a square pulse, positive on pin 9, and approximately 12 miscroseconds in duration. For the duration of this pulse, Q_2 is saturated and applies a magnetic potential to the core in toroid assembly T_2 through pins 1 and 2. This magnitude and duration of the magnetic potential results in a partial switching of the magnetic flux in the core of T_2. The amount of flux switched with one pul·,e is approximately equal to one tenth of the peak change in the magnetic flux when the core is driven from a state of residual induction to a state of opposite saturated induction.

Ten input pulses to a decade stage are required to switch the core. As the tenth pulse saturates the core, the impedance of winding 1-2 decreases, current through R_8 increases, and winding 3-4 becomes more positive. Transistor Q_5 turns on, causing a voltage drop in winding 7-8. This voltage drop induces a more positive signal at pin 3 in a regenerative manner until the core is switched to a state of opposite saturated induction. At this point, a quiescent state is again established, and the core is in the original state.

The additional input pulses switch the core in an incremental manner and repeat the cycle. When the core is reset with Q_3, an output pulse appears on T_2, winding 9-10, similar to the input pulse on T_1, winding 9-10. The following stages comprising T_3, T_4, and T_5 are similar decade counters. Between pulses, the magnetic counter in the FMU-72/B consumes no power.

5. Binary Magnetic Counter

The function of the binary magnetic counter is to count a presettable number of input pulses, then provide an output signal for event. Thus, a firing delay of 20 minutes to 36 hours in 35 increments is provided. The counter is composed of seven binary stages, each requiring two inputs for one output. Each stage is either "set" or "clear" and has an output as it goes from

clear to set. There is no output from "set" to "clear". Initially all cores are cleared, except those selected by the selector switch to be set. To set a core initially, current is applied to both the clear and set cores simultaneously. The 12-turn set windings prevail over the eight-turn clear windings, leaving the core set.

After the binary counter has been cleared and set, the counter operates in a conventional binary manner until all cores are cleared. The next input pulse sets the input stage, causing an output which sets the second stage. This process continues until the last stage switches from clear to set, resulting in an output pulse for event. If all stages have been initially cleared, the first pulse into the binary counter produces the event.

The operation of a single stage is as follows (see figure 21). Assume the stage has been cleared. Winding 1-2 presents a high impedance to a negative-going signal at pin 2. Capacitor C_3 is charged to B+ through R_2. With a positive input on the gate, CR_1 fires, discharging C_3 through winding 1-2, and causing the dotted pin 1 to be positive with respect to negative-going pin 2.

Since the toroid assembly is also a transformer, pin 3 is driven positive with respect to pin 4, firing CR_3 for the following stage. Winding 5-6 provides positive feedback to cancel the magnetic field on T_1 from winding 1-2 due to the accumulated charge on C_2. Windings 7-8 and 9-10 are not used again after the initial clear-set.

With the core set, winding 1-2 presents a very low impedance to negative-going signals on pin 2. Signals of negative polarity tend to drive the core from a state of residual induction, toward the nearer state of saturation. When the following pulse fires CR_1, C_3 cannot be discharged by driving pin 2 negative. Consequently, the cathode of CR_1 goes positive, transferring part of the charge on C_3 to C_2. Current through the SCR decreases and conduction stops. Then the charged C_2 discharges through the 8.2-ohm resistor and winding 1-2, driving pin 2 positive. In subsequent stages, capacitors corresponding to C_2 also provide energy for the feedback winding.

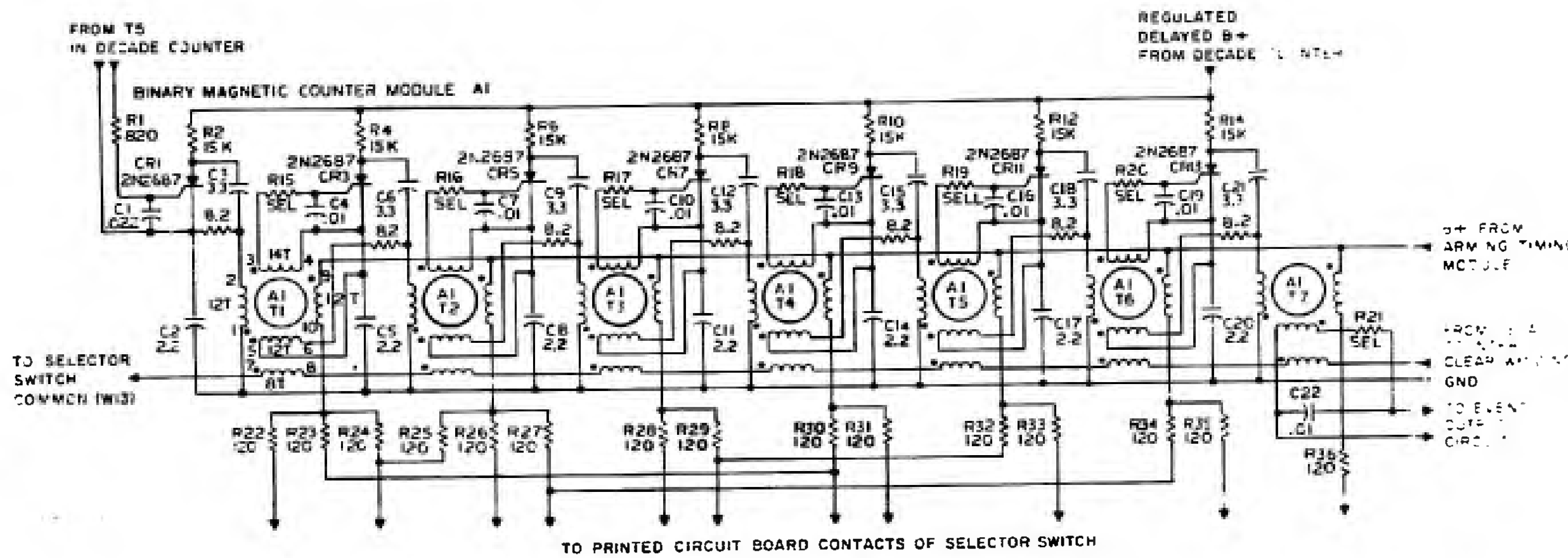


Figure 21. Binary-Magnetic-Counter-Circuit Schematic

The opposite magnetic field in T_1 switches the core to the opposite state of saturation. The signal at pin 3 is negative with respect to pin 4; therefore, CR_3 does not fire and the stage has no output for this portion of the cycle. An 8. 2-ohm resistor provides a high impedance path at the time C_3 is trying to drive pin 2 negative. When C_3 is discharged, the 8. 2-ohm resistor provides a discharge path for C_2, and the current C_2 drives pin 2 positive. Resistor R_1 and capacitor C_1 filter out noise. Successive stages in the binary counter operate in a similar manner.

6. Event Output

The event output circuit, when triggered, switches energy stored in capacitors through an SCR into the bridge wire of the detonator, initiating the detonator which, in turn, initiates the booster. The energy storage capacitors C_2 and C_3, shown in figures 11 and 28, are connected to the detonator through CR_2 and Sections D and E of the "armed" rotor switch, shown in figures 22 and 28. The capacitors charge through R3 to the potential of the delayed B+. Energy from the binary counter gates CR2 on and effectively connects the charged capacitors to the detonator, causing subsequent function of the detonator, booster, and bomb. The booster contains 45 grams RDX.

Silicon-controlled rectifier CR2 may be triggered by the preset function of the timing circuits or by operation of the antidisturbance (A-D) switch. If the bomb fuze is moved or tampered with after impact, the normally open A-D switch momentarily closes, connecting the delayed B+ to the gate of event CR2, thereby detonating the bomb.

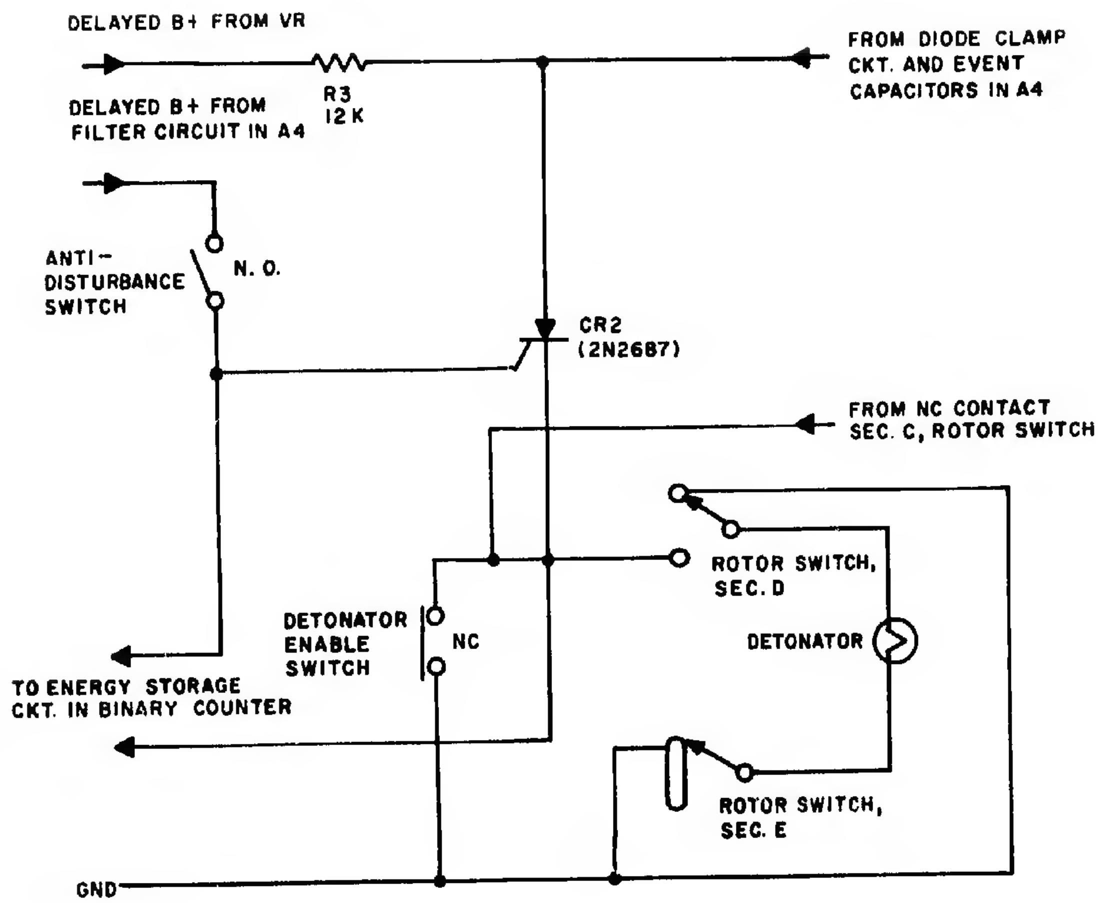


Figure 22. Simplified Event-Output-Circuit Schematic

G. OPERATION OF OTHER SUBASSEMBLIES INVOLVED IN FUZE EVENTING

1. Impact Switch (figures 23 and 28)

The impact switch is omnidirectional, suspended-mass-type switch which closes momentarily on impact to gate on silicon-controlled rectifier CR1 in the impact delay circuit (paragraph F-1).

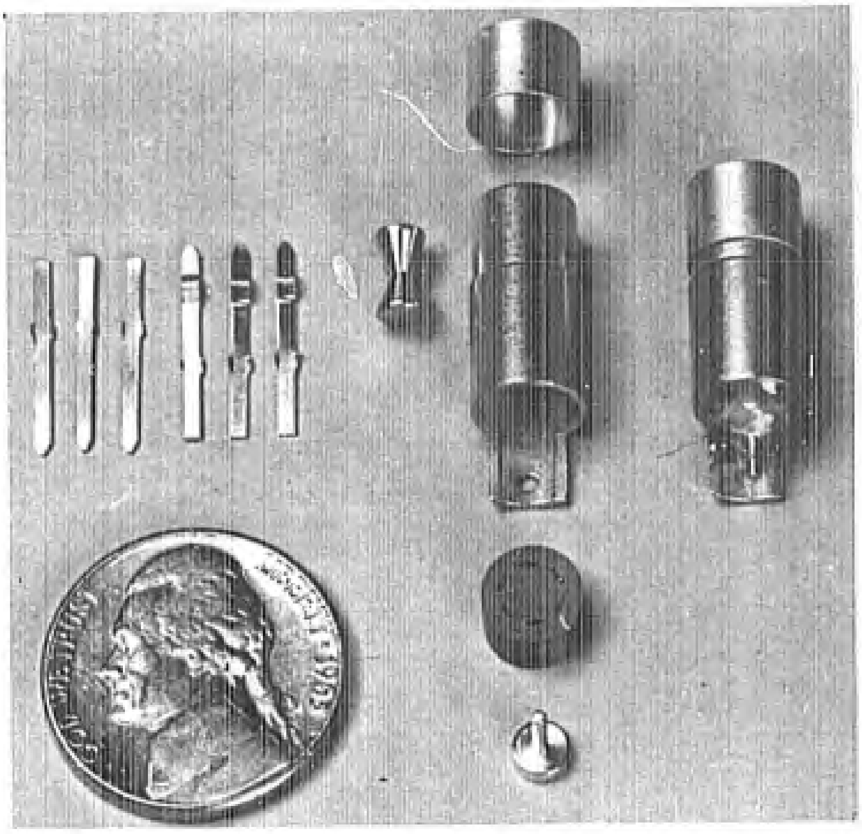


Figure 23. Impact Switch

2. Detonator Enable Switch (figures 24 and 28)

The detonator enable switch provides a short across the detonator after arming. It prevents fuze functioning until the bomb impacts. Electrically and physically, the switch is similar to the safing switch.

3. Electric Detonator (figures 25 and 28)

The detonator is the first member of the explosive train of the fuze. Its function is to initiate the booster, the second member of the train. The detonator in the FMU-72/B fuze is comprised of 320 mg of lead azide/PETN in an aluminum case approximately 9/32 inch in diameter and 1/2-inch long. The case is sealed with a phenolic. Lead wires from a low-resistance bridge within the case are both connected to ground through the normally

closed contacts of two sections of the rotor switch, shorting out the detonator before arming. At the time of arming, rotor-switch sections D and E connect one lead to the cathode of CR_2 and the detonator enable switch and the other to ground. Until earth impact, at which time the detonator enable switch opens, any inadvertent firing of CR_2 will be shorted to ground, precluding firing of the detonator. The discharge of event capacitors C2 and C3 fires the detonator. The detonator perforates the plug in the fuze-case detonator hole and initiates the booster located in the fuze-case cavity above the detonator.

4. Antidisturbance Switch (figures 26 and 28)

The antidisturbance switch provides momentary switch closure to initiate the explosive train in event the bomb, or fuze, is tampered with after arming and impact. The switch is omnidirectional and consists of an outer shell contact, an inner gear contact, and a ball that is free to roll between the contacts. At rest, the ball is positioned in one of the shell depressions. If the switch is turned, or otherwise disturbed, the ball rolls over the high portion of the shell contact and makes momentary contact with a gear-shaped contact, completing the switch circuit to gate on the event-output-circuit SCR, CR2. Since delayed B+ from the impact delay circuit has been available to charge the capacitors connected to the anode of the SCR, the SCR will fire and the event capacitor discharge will initiate the detonator.

5. Booster (figure 27)

The booster contains approximately 45 grams of RDX which, when initiated by the electric detonator, explodes high order and causes high-order detonation of the bomb. The booster is placed in the formed recess of the fuze container (figure 1) at the time the fuze is installed in the fuze well of the bomb.

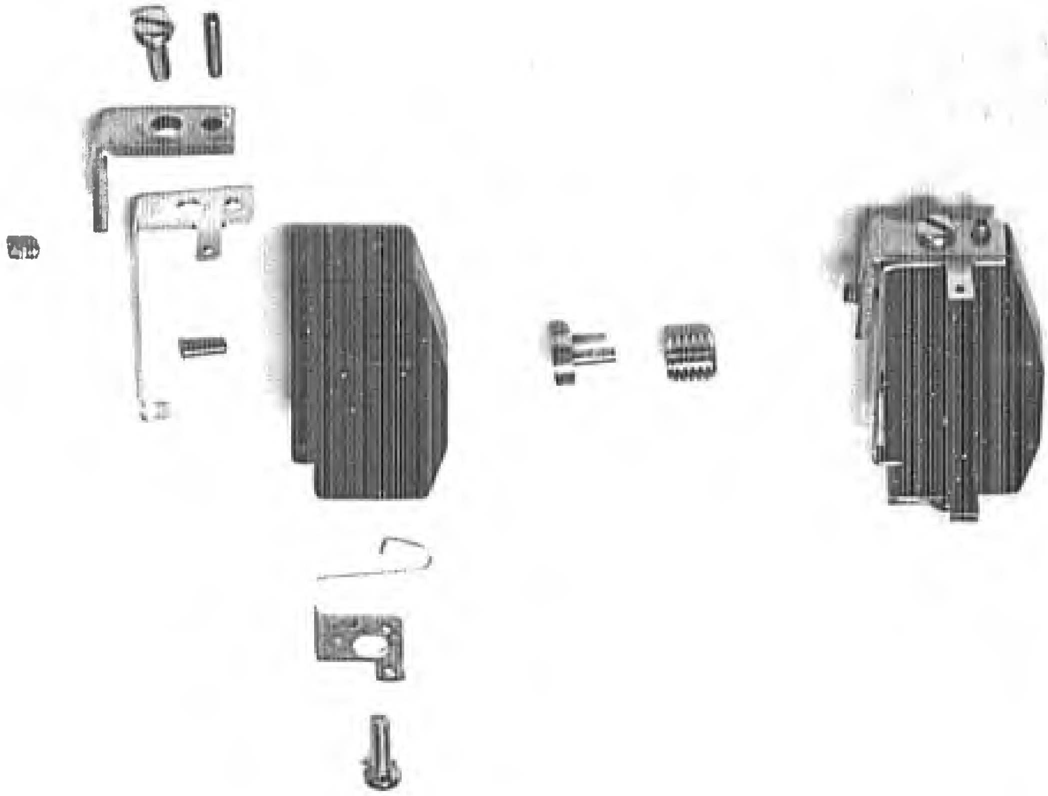


Figure 24. Detonator Enable Switch

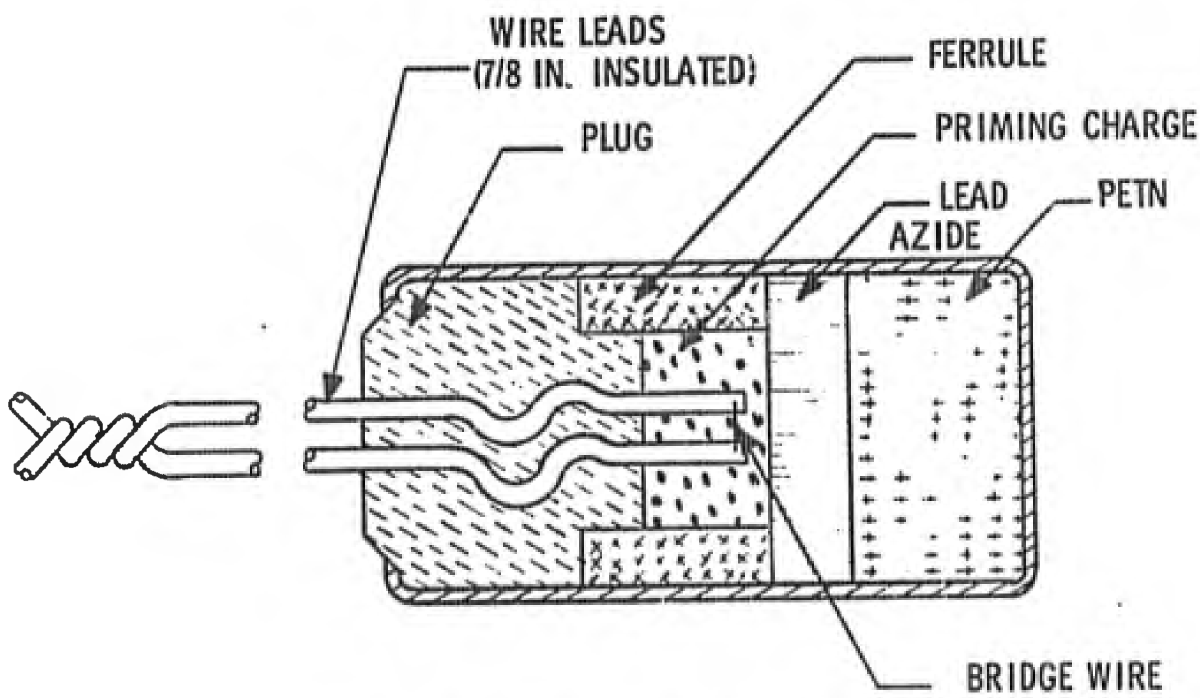


Figure 25. Electric Detonator

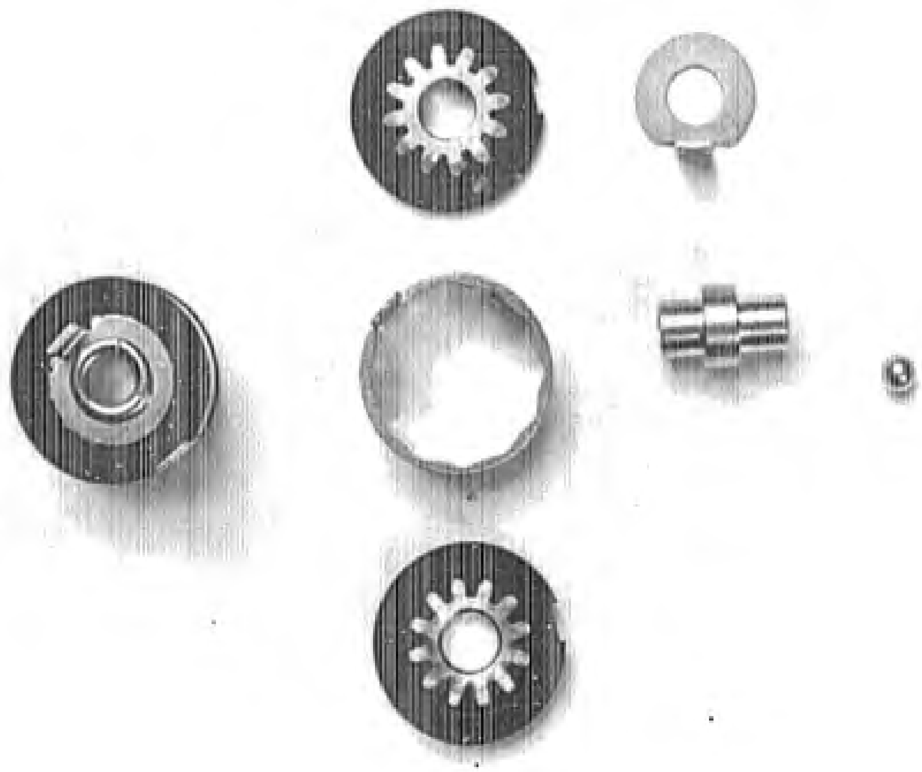


Figure 26. Antidisturbance Switch

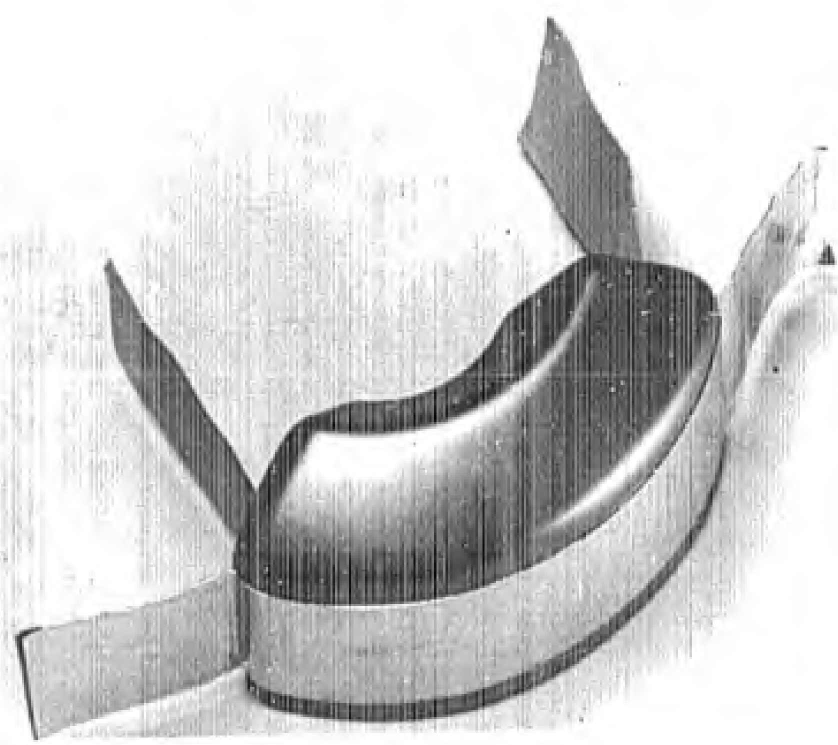


Figure 27. High-Explosive Booster

SECTION III

DESIRED PERFORMANCE VALUES

A. GENERAL

This section contains the desired performance values for the various subassemblies whose operational characteristics were described in Section I. The performance categories for which values are given for the subassembly spectrum are:

- Pull Loads on Lanyard Assembly
- Output Voltages of Power Source
- Oscillator Output Period
- Time Delay - Arming
- Time Delays - Antidisturbance
- Switch Functions
- Shock Pulse
- High-Order Detonation

The performance-value information is given in order of the fuze-operation events beginning with fuze initiation and terminating with booster initiation. When expedient, the information is given in tabular form.

B. PERFORMANCE VALUES

1. <u>Performance Values - Subassemblies Associated With Fuze Initiation</u>

The three subassemblies involved in the initiation of the fuze are the swivel and link assembly, the battery firing device (BFD), and the ammonia battery. The required performance values follow.

a. Swivel and Link Assembly

The three parts of the assembly, end link, swivel eye, and swivel link, are required to stand a minimum load of 100 pounds.

b. Battery Firing Device

The following values are prescribed for the BFD:

Item	Value
• Maximum pull on lanyard assembly which will be sufficient to move the lanyard cup until it is approximately flush with the lanyard housing	35 lb
• Minimum impact velocity of firing pin, measured within two inches of the end of the device	34 fps

c. Ammonia Battery

The electrical requirements are as follows:

- Function initiation shall be by means of the BFD (see preceding paragraph).
- The output voltage shall rise to 9.0 vdc in 1.25 seconds maximum from the time the firing pin contacts the percussion cap.
- The battery shall provide 14.0 vdc maximum for the first one minute after initiation, 12.0 vdc for the next 36 hours, and a minimum of 6.7 vdc.
- When operated at or above ambient temperature of +125°F, the battery voltage shall not exceed 12.0 vdc or be below 6.7 vdc.

2. Performance Values of Individual Subassemblies of the Electronic Assembly Associated with Fuze Arming and Eventing

There are required performance values for the subassemblies that comprise the electronic assembly, as well as performance values for the assembly itself and the selector-switch assembly. Table I summarizes the required values and capabilities for the two counter assemblies. Table II summarizes the required values for the other assemblies. The values in the two tables are bench-test performance values when supplied with specified B+ supply voltages.

3. Performance Values of Other Subassemblies Associated with Fuze Arming

In addition to the selector switch and the subassemblies of the electronic assembly, two other subassemblies function to arm the fuze: the rotor assembly and the bellows motors. A third component, the safing switch, is associated with arming as a safety device. This item prevents arming if the fuzed bomb is ejected accidentally at extremely low altitudes. Performance values for the three components follows.

a. Safing Switch

The performance value for this component are:

- The switch circuit shall open and remain open when it is subjected to a half-sine-wave shock of 125 ± 5-g maximum peak amplitude in each of three mutually perpendicular axes with a duration of 5.0 ± 1.0 milliseconds at 10 percent amplitude. (The lateral axis shall be in the direction of the arm contact.)

- The switch circuit shall remain closed when it is subjected to a half-sine-wave shock of 50-g peak amplitude in each of three mutually perpendicular axes with a duration of 5.0 ± 1.0 milliseconds at 10 percent amplitude. (The lateral axis shall be in the direction of the arm contact.)

TABLE I. PERFORMANCE VALUE REQUIREMENTS OF THE SELECTOR SWITCH AND COUNTER ASSEMBLIES

SUBASSEMBLIES	OUTPUT PULSE TIME DELAY	OUTPUT PULSE AMPLITUDE	PRESETTING CAPABILITY	INPUT PULSE-COUNTING CAPABILITY	FUZE-SETTING CAPABILITY
SELECTOR-SWITCH ASSEMBLY	N A	N A	N.A	N A	THE SELECTOR SWITCH SHALL BE CAPABLE OF MAKING 35 FUNCTION TIME SETTINGS IN INCREMENTS AS FOLLOWS: 1 3 TO 5 HR IN 1 3-HR INCREMENTS. 5 TO 16 HR IN 1 0-HR INCREMENTS 16 TO 30 HR IN 2 0-HR INCREMENTS. AND 30 TO 36 HR IN 3 0-HR INCREMENTS. IT SHALL ALSO BE CAPABLE OF SETTING THE FUZE TO THE SAFE POSITION.
BI-MAG COUNTER ASSEMBLY	THE ASSEMBLY SHALL BE CAPABLE OF BEING PRESET. WITH D-C B- VOLTAGE OF 6.0 ± 0.1 VOLTS APPLIED TO PRODUCE AN OUTPUT PULSE ONLY AFTER THE NUMBER OF INPUT PULSES EQUAL THE PRESET NUMBERS.	THE AMPLITUDE OF THE OUTPUT PULSE SHALL BE 0.9 VOLTS MINIMUM.	THE ASSEMBLY SHALL BE PRESETTABLE TO ANY WHOLE NUMBER BETWEEN 1 AND 128.	THE ASSEMBLY SHALL BE CAPABLE OF COUNTING INPUT PULSES AT FREQUENCIES UP TO 5 HZ.	N A
DECADE COUNTER ASSEMBLY	AN OUTPUT PULSE SHALL APPEAR ACROSS THE OUTPUT TERMINALS OF THE ASSEMBLY WHEN 10^{4} - 10 PULSES HAVE BEEN APPLIED TO THE COUNTER INPUT. THE B- SUPPLY VOLTAGE APPLICATION SHALL BE 6.0 0.1 VDC.	THE AMPLITUDE OF THE OUTPUT PULSE ACROSS THE TERMINALS SHALL BE 4.0 VDC, MINIMUM.	N A	N A	N A

TABLE II. BENCH TEST PERFORMANCE VALUES FOR THE REMAINING ELECTRONICS SUBASSEMBLIES

SUBASSEMBLY	OUTPUT VOLTAGE DELAY TIME	OUTPUT PERIOD	VOLTAGE OUTPUT
ARMING TIMER AND SET CIRCUIT ASSEMBLY	AN OUTPUT VOLTAGE SHALL APPEAR ACROSS THE OUTPUT TERMINALS AT 5.050 ± 0.150 SEC MEASURED FROM THE INSTANT OF POWER APPLICATION TO THE B+ TERMINAL. WHEN ENERGIZED BY THE AMMONIA BATTERY, THE FUZE SHALL ARM AT 6.0 + 1.5, -1.0 SEC.	N/A	N/A
IMPACT CIRCUIT ASSEMBLY	WITH 9.0 ± 0.1 VDC APPLIED AND THE TWO CONTACTS OF THE IMPACT SWITCH EXTERNALLY SHORTED MOMENTARILY, AN OUTPUT VOLTAGE SHALL APPEAR ACROSS TERMINALS EV B+ AND GND AT 33.0 ± 10.0 SEC, MEASURED FROM INSTANT OF SWITCH SHORTING. WHEN THE APPLIED VOLTAGE IS 9.0 ± 1.8 VDC, THE OUTPUT VOLTAGE SHALL BE 6.0 ± 0.1 VDC.	N/A	N/A
MAGNETIC OSCILLATOR ASSEMBLY	N/A	WHEN OPERATION AT B+ SUPPLY VOLTAGE OF 9.0 ± 1.8 VDC, THE OUTPUT PERIOD SHALL BE 120 ± 2.0 MS.	N/A
CLEAR AND SET CIRCUIT	N/A	FUNCTIONING SHALL OCCUR AT 33.0 ± 10.0 SEC AFTER THE IMPACT SWITCH IS CLOSED WHILE THE FUZE IS OPERATING AT SUPPLY VOLTAGES FROM 7.2 TO 14.0 VDC.	N/A
VOLTAGE REGULATOR CIRCUIT	N/A	N/A	WITH 9.0 ± 0.1 VDC APPLIED TO THE B+ AND GND TERMINALS, THE VOLTAGE BETWEEN THE COUNTER B+ AND GND TERMINALS SHALL BE 5.9 VDC MINIMUM AND 6.1 VDC MAXIMUM.
BELLOWS MOTOR CIRCUIT	N/A	N/A	WITH 9.0 ± 0.1 VDC APPLIED BETWEEN ARM B+ AND GND, AND A 3.6 ± 0.3 OHM RESISTIVE LOAD CONNECTED BETWEEN ARM OUTPUT AND GND, AN EXPONENTIALLY DECAYING VOLTAGE SHALL APPEAR ACROSS THE RESISTIVE LOAD WHEN AN INITIAL 6.0 VDC (MIN.) TRIGGER PULSE IS APPLIED BETWEEN ARM INPUT AND GND. THE DECAY RATE SHALL BE SUCH THAT AT 0.2 MS FROM THE START OF THE PULSE, THE AMPLITUDE SHALL BE 4.5 VDC MINIMUM.
EVENT OUTPUT	THE FUZE SHALL BE CAPABLE OF BEING PRESET TO PRODUCE AN OUTPUT VOLTAGE AT THE EVENT OUTPUT TERMINAL AT THE FOLLOWING TIMES, MEASURED FROM THE INSTANT OF IMPACT SWITCH CLOSURE: (1) 1/3 TO 5 HR IN 1/3 HR INCREMENTS. (2) 5 TO 16 HR IN 1.0 HR INCREMENTS. (3) 16 TO 30 HR IN 2 HR INCREMENTS; AND (4) 30 TO 36 HR IN 3 HR INCREMENTS. EVENT TIMES SHALL AGREE WITH THE PRE-SET VALUES TO WITHIN 5.0 WHEN THE FUZE IS OPERATING AT A B+ VOLTAGE OF 9.0 ± 1.0 VDC.	N/A	WITH THE EXCEPTION OF THE FOLLOWING TEST CONDITIONS, THE RESULTS ARE THE SAME AS THOSE OF THE BELLOWS MOTOR CIRCUIT: (1) 7.2 ± 0.1 VDC APPLIED BETWEEN POST IMPACT B+ AND GND. (2) 2.7 ± 0.1 OHM RESISTIVE LOAD BETWEEN EVENT OUTPUT AND GND; AND (3) TRIGGER PULSE OF 4.0 VDC APPLIED BETWEEN COUNTER OUTPUT AND GND. (4) A DECAY RATE THAT AT 0.2 MS FROM THE START OF THE PULSE THE AMPLITUDE WILL BE 2.0 VDC MIN.

- The switch circuit shall remain closed when the switch is subjected to a half-sine-wave shock of 220-g minimum peak amplitude in a direction 200 degrees + 10 degrees clockwise from the lateral axis (previous two paragraphs), with a duration of 5.0 ± 2.0 milliseconds at 10-percent amplitude.

b. Rotor Assembly and Bellows Motors

The rotor assembly must be rotated 90 degrees within 20 milliseconds so (a) the switching actions will have taken place, and (b) the detonator will have been aligned with the booster. Since the two bellows motors perform the motive power for rotor rotation in a given time period, their time-performance values shall be considered the performance values of the rotor assembly.

- The bellows motors shall overcome a 14 + 2-pound detent load and expand a minimum of 1.0 inch along the longitudinal axis against a 6 + 2- pound spring load in less than 20 milliseconds when supplied with firing energy from either a capacitor discharge of 6 vdc from 200 μf or from direct application of 1.0 ampere.

- The bellows motors shall not initiate when supplied with a 50-milliampere pulse for 30 seconds minimum.

4. Performance Values of Other Subassemblies Associated with Fuze Eventing

In addition to the selector switch, the time base oscillator, the counter, and the output circuit, the following subassemblies function to fire the explosive train and finally explode the bomb: the impact switch, the detonator enable switch, the antidisturbance switch (the antidisturbance switch detonates the bomb instantly if the bomb is disturbed after impact), the detonator, and the booster. Performance-value requirements for the four subassemblies follow.

a. Impact Switch

The performance-value requirements for the impact switch are:

- The switch circuit shall momentarily close when the device is subjected to a half-sine-wave shock pulse of 500-g maximum amplitude in any direction. A shock-time duration of 3.0 ± 0.5 millisecond at 10-percent amplitude is specified.

- The switch circuit shall not close when the device is subjected to a shock of 250-g minimum amplitude in any direction. A shock-time duration of 3.0 ± 0.5 milliseconds at 10-percent amplitude is specified.

b. Detonator Enable Switch

The performance-value requirements for the detonator enable switch are:

- The switch shall open and remain open when the device is subjected to a half-sine-wave shock of 500-g maximum peak amplitude with a duration of 3.0 ± 0.5 millisecond at 10-percent amplitude in the longitudinal direction and in a second direction which is (a) normal to the longitudinal axis, (b) parallel with the rod and slug of the switch, and (c) radial from the center of the fuze.

- The switch circuit shall remain closed when the device is subjected to a half-sine-wave shock of 250-g minimum peak amplitude with a duration of 3.0 ± 0.5 milliseconds at 10-percent amplitude in the directions listed above.

- The switch circuit shall remain closed when the device is subjected to a half-sine-wave shock of 500-g minimum peak amplitude with a duration of 3.0 ± 0.5 milliseconds at 10-percent amplitude in a direction which is mutually perpendicular to the longitudinal axis and the axis parallel with the rod and slug of the switch.

c. Antidisturbance Switch

When closed momentarily, the antidisturbance switch shall cause an output signal to occur at the event output terminal if:

- The fuze rotor assembly is in the armed position, and
- After a short delay the impact switch closes, and the bomb comes to rest.

d. Electric Detonator

The performance requirements for the electric detonator are specified as follows:

- Firing of the detonator when it is in-line with the booster shall cause high-order detonation* to take place in the booster.
- A qualification test requires the following: The detonator shall fire on the first attempt and shall cause perforation of a 1.225-inch diameter x 1/8-inch thick-lead disc to a diameter of not less than 1/4 inch, minimum, when energy of 1 ampere is applied. The detonator shall not fire when supplied with 130 ma for 30 seconds.
- The detonator shall not detonate the booster when the detonator is fired in the out-of-line position.

e. Booster and Tape Assembly

The performance requirement for the booster component of the booster and tape assembly is specified as follows: Detonation of the booster shall be high order and shall cause high-order detonation in a bomb fuzed by the FMU-72/B fuze assembly.

The booster assembly shall be detonated by connecting a voltage source capable of delivering 1.5 ampere across the detonator terminals.

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* Detonation is an exothermic chemical reaction that propagates with such rapidity that the rate of advance of the reaction zone into the unreacted material exceeds the velocity of sound in the unreacted material. High-order detonation is defined as that in which the detonation rate is equal to, or greater than, the stable detonation velocity of the explosive. In stable detonation, the rate of advance of the reaction zone continues without diminution through the unreacted material. High-order detonation for this type of detonator is defined as that order of detonation which will cause a 0.050-inch perforation in a stainless steel witness plate.

SECTION IV

REQUIREMENTS OF FUZE SUBASSEMBLIES TO WITHSTAND THE EFFECTS OF ENVIRONMENTS

A. GENERAL

The end item, the FMU-72/B Bomb Fuze, is required to operate satisfactorily within prescribed ranges and limits of several environments. In addition, specifications have been set forth for nine of the fuze subassemblies, requiring them to meet some, or all, of certain MIL-STD, MIL-E, and MIL-S requirements in these five environmental categories:

- Temperature
- Vibration
- Rough handling
- Impact
- Acceleration stress

B. REQUIREMENTS FOR SUBASSEMBLIES

Table III summarizes the environmental requirements for the following subassemblies: selector switch, ammonia battery, electronic assemblies, impact switch, antidisturbance switch, safing switch, detonator enable switch, bellows motors, detonator, and booster. In the case of the electronic assemblies, shock requirements are given for most of the component categories that comprise the assemblies.

TABLE III. ENVIRONMENTAL REQUIREMENTS FOR THE FMU-72/B SUBASSEMBLIES

SUBASSEMBLY	ENVIRONMENTS			
	TEMPERATURE	VIBRATION	ROUGH HANDLING	IMPACT
SELECTOR SWITCH ASSEMBLY	-65°F TO +170°F	TRANSPORTATION (MIL-STD-303A)	N/A	3000 G FOR 1.0 MS
AMMONIA BATTERY	-65°F TO +160°F AND MIL-STD-304 (TEMPERATURE AND HUMIDITY)	AIRCRAFT VIBRATION (MIL-E-5272C) TRANSPORTATION VIBRATION (MIL-STD-303A)	MIL-STD-300, JOLT MIL-STD-301, JUMBLE MIL-STD-302, 40-FT DROP MIL-STD-307A, JETTISON MIL-STD-358, 5-FT DROP	3000 G FOR 1.0 MS
ELECTRONIC ASSEMBLIES	-65°F TO +160°F	N/A	N/A	6000 G FOR 0.5 MS (CAPACITORS, CHOKES, CORES, TRANSISTORS, AND DIODES)
IMPACT SWITCH	-65 F TO +250 F	N/A	N/A	SEE PARAGRAPH III.B.4.a
ANTIDISTURBANCE SWITCH	-65 F TO +160 F	N/A	N/A	
SAFING SWITCH AND DETONATOR ENABLE SWITCH	-65 F TO +160 F	N/A	N/A	SEE PARAGRAPHS III.B.3.a AND III.B.4.b
BELLOWS MOTORS	-65 F TO 160 F	MIL-STD-202B (H. F. VIBRATION) MIL-STD-303A (TRANSPORTATION VIBRATION)	MIL-STD-302, 40-FT DROP	6000 G FOR 0.5 MS
DETONATOR	-65 F TO 160 F	N/A	N/A	6000 G FOR 0.5 MS
BOOSTER	-65 F TO 160 F	N/A	N/A	N A

SECTION V

SUPPLEMENTARY SCHEMATIC

Figure 28 is simplified schematic of the FMU-72/B fuze system which is made up of fuze electronics and switch subassemblies. Unfolded, the schematic may be used during consideration of Section II of this text.

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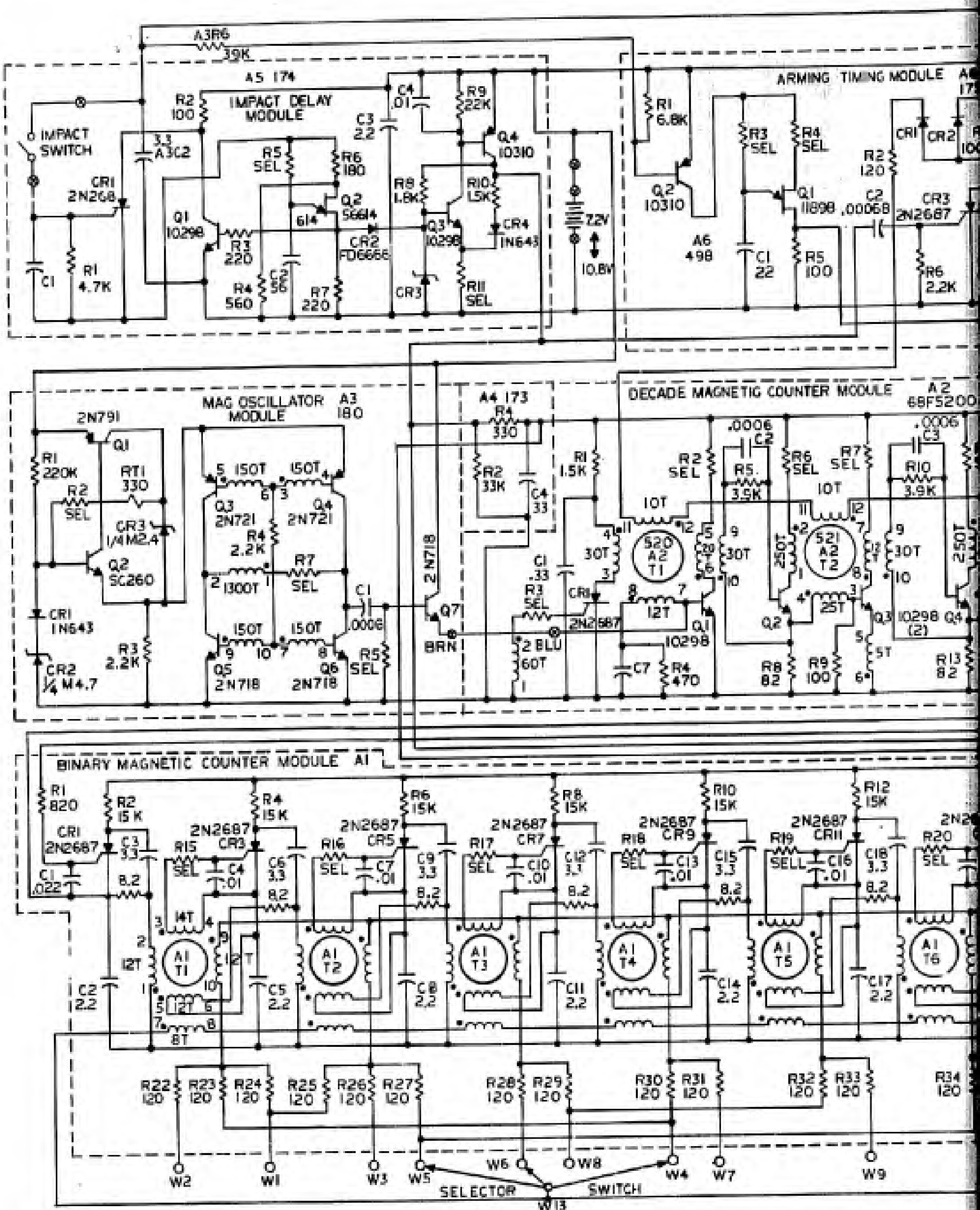
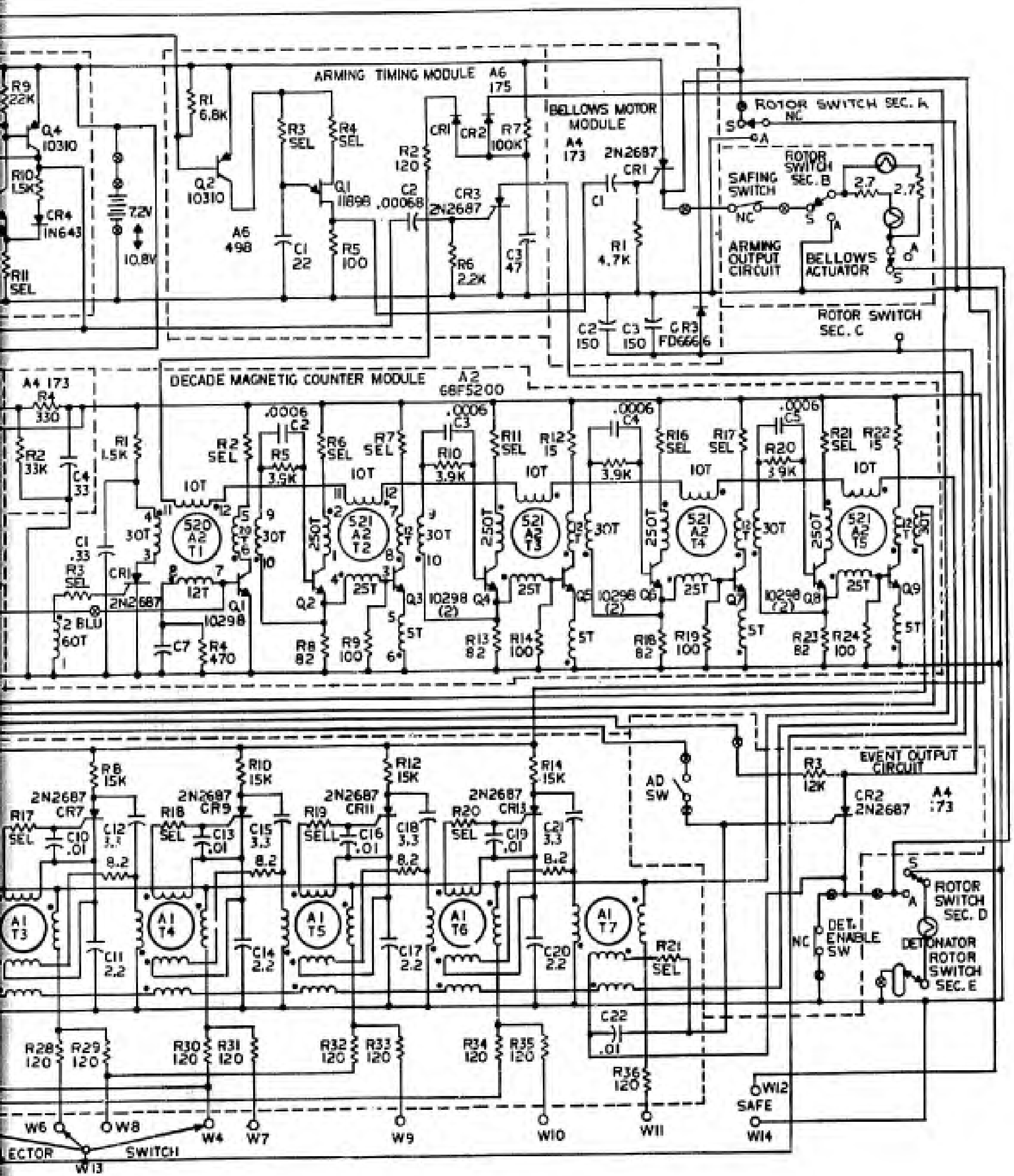


Figure 28. Simplified Schematic of FMU-72



ure 28. Simplified Schematic of FMU-72/B Bomb Fuze

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13. ABSTRACT
This document contains detailed descriptions of the FMU-72/B bomb fuze, the operation of the fuze, and the operation of the fuze subassemblies with their relationship to the arming and event functioning of the fuze, the performance values for the subassemblies with acceptable tolerances, and the effects of temperature, vibration, rough handling, impact, and G-force environments on the fuze subassemblies.

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